ANNUAL REPORT TO CONGRESS—FISCAL YEAR 1996

A REPORT BY THE COUNCIL OF THE STRATEGIC ENVIRONMENTAL RESEARCH AND DEVELOPMENT PROGRAM

March 1997

This document was prepared for the Executive Director, Strategic Environmental Research and Development Program (SERDP) by HydroGeoLogic, Inc. and LABAT-ANDERSON INCORPORATED under Contract Number DACA39-95-D-0023. Questions regarding the SERDP should be directed to the SERDP Program Office located at 901 North Stuart Street, Suite 303, Arlington VA, 22203.

SERDP

DoD EPA DOE

Strategic Environmental Research and Development Program

Improving Mission Readiness Through Environmental Research

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-AQ # M97-07-4720

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PREFACE

The Strategic Environmental Research and Development Program was established by Title 10 U.S.C. §§2901-2904. The Strategic Environmental Research and Development Program addresses environmental matters of concern to the Department of Defense and the Department of Energy. It is a Department of Defense Program planned, managed, and executed in full partnership with the Department of Energy and Environmental Protection Agency with participation by numerous other Federal and non-Federal organizations.

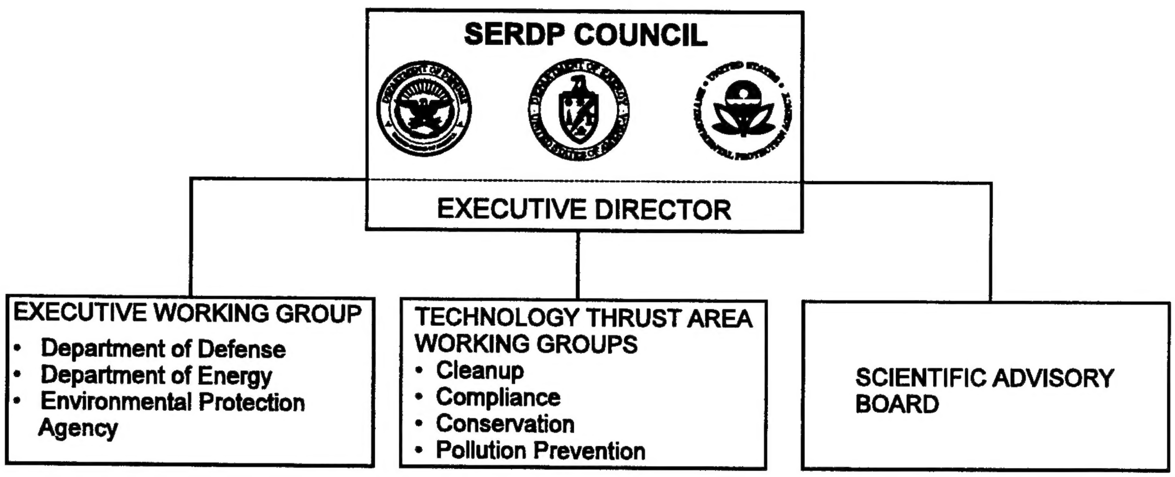

Figure I-1. SERDP Organization

This report of the SERDP Council provides a summary of SERDP's activities and most significant accomplishments during fiscal year 1996, its plans for fiscal year 1997 and new initiatives to be addressed in fiscal year 1998.

SERDP Council

Title 10, U.S.C. §2902 established the Strategic Environmental Research and Development Program Council to oversee management of SERDP. Specifically, this Council prescribes policies and procedures to implement the SERDP and may enter into contracts, grants, and other agreements in accordance with other applicable law, to carry out the purposes of SERDP. Congress intended the Council to be a multi-agency membership body to promote maximum exchange of information and to minimize duplication of environmental related research, development, and demonstration activities through close coordination with the military departments and Defense Agencies, the Department of Energy, the Environmental Protection Agency, the National Oceanic and Atmospheric Administration, the National Aeronautics and Space Administration, other departments and agencies of the Federal

Government and State and local governments, and other organizations engaged in environmental related research.

Consistent with the SERDP statute and with facilitating multi-agency cooperation, the Department of Defense designates a member of the Council as chairperson for each odd-numbered fiscal year and the Secretary of Energy designates a member of the Council to serve as chair for each even-numbered year.

Council Members

Mr. Alvin Alm
Department of Energy
Environmental Management

Dr. Richard Chait
Department of the Army
Research, Development and Acquisition

Colonel Joseph Corcoran
Department of Defense
Joint Chiefs of Staff

Colonel Richard Drawbaugh
Department of the Air Force
Environment, Safety, and Occupational Health

Ms. Sherri Goodman
Department of Defense
Environmental Security

Dr. Robert Huggett
Environmental Protection Agency Research and Development

Dr. Anita Jones (Alternate Chair)
Department of Defense
Research and Engineering

Dr. Martha Krebs (Chair)
Department of Energy
Energy Research

Dr. Victor Reis
Department of Energy
Defense Programs

Dr. Fred Saalfeld
Department of the Navy
Naval Research

Dr. John Harrison
Strategic Environmental Research and Development Program

Captain Gary Steinfort
U.S. Coast Guard
Research and Development

SERDP Scientific Advisory Board

The SERDP Scientific Advisory Board (SAB), established in accordance with the SERDP statute, assures the Council's primary focus on technical quality. The SAB may make recommendations to the Council regarding technologies, research, projects, programs, activities, and, if appropriate, funding within the scope of the SERDP.

The SAB is composed of no more than 14 members who are jointly appointed by the Secretary of Defense and the Secretary of Energy in consultation with the Administrator of the Environmental Protection Agency. To assure a program that is congruent with the

Administration's goals, the Science Advisor to the President (or his designee) is a statutory member of the SAB. Similarly, the Administrator of the National Oceanic and Atmospheric Administration, or his designee, is a statutory SAB member to ensure that regional and global environmental issues are appropriately addressed in SERDP.

The *FY 1996 Scientific Advisory Board Annual Report* to Congress reviews the specific actions taken and recommendations made by the SAB during fiscal year 1996. The report was provided to Congress in March 1997.

Scientific Advisory Board Members

Dr. Rosina Bierbaum
Office of the Science Advisor to the President

Dr. Rita R. Colwell #
University of Maryland Biotechnology Institute

Mr. Richard A. Carpenter
Environmental Consultant

Mr. Richard A. Conway
Union Carbide Corporation

Mr. Amos S. Eno - Vice Chair
National Fish & Wildlife Foundation

Ms. Mary A. Gade #
Illinois Environmental Protection Agency

Dr. Raymond C. Loehr
University of Texas at Austin

Dr. Marvin K. Moss
University of North Carolina at Wilmington

Dr. Ned A. Ostenso *
National Oceanic and Atmospheric Administration

Dr. Frank L. Parker
Vanderbilt University

Dr. Michael J. Ryan
Bechtel Environmental, Inc

Dr. Lydia Thomas
The MITRETEK Systems

Dr. Jean'ne Shreeve
University of Idaho

Dr. Robert Watson *
Office of the Science Advisory to the President

Dr. Walter J. Weber, Jr. (Chair)
University of Michigan

Dr. Karen Wetterhahn
Dartmouth College

Mr. Robert S. Winokur
National Oceanic and Atmospheric Administration

Mr. Randolph Wood
Nebraska Department of Environmental Quality

- Membership term expired during FY 1996
* - Served as a permanent member during part of FY 1996

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I. OVERVIEW

Introduction

The Strategic Environmental Research and Development Program (SERDP) is the Department of Defense's (DoD) corporate environmental science and technology (S&T) program and technology transfer mechanism. It fully leverages the complementary programs found within the Army, Navy, and Air Force, and those of the Department of Energy (DOE) and the Environmental Protection Agency (EPA). The SERDP Council has implemented policies that take full advantage of the intrinsic capabilities of the participating organizations and has directed the development and execution of the Program consistent with the SERDP authorizing statute.

DoD environmental concerns may be divided into two broad categories: (1) those which impact training, logistics, and combat operations; and (2) those which have cost impacts on the supporting infrastructure. In either case, these concerns can have negative impacts on the Department's ability to perform its primary mission of maintaining military readiness for national defense. SERDP strives to minimize or eliminate major negative impacts of environmental concerns or requirements on DoD's ability to conduct this mission. Current DoD costs of environmental compliance, cleanup, and conservation are significant. Development and application of innovative environmental technologies will reduce costs, environmental risks, and/or time required to resolve environmental problems in these areas while simultaneously enhancing safety and health. Equally important, the development and application of innovative pollution prevention technologies serves to reduce or eliminate waste problems before they occur.

Thus, SERDP is improving mission readiness through environmental research by:

- Accelerating cost-effective cleanup of contaminated Defense sites;
- Facilitating full compliance with environmental laws and regulations at reduced cost;
- Enhancing training, testing, and operational readiness through prudent land management and conservation measures; and
- Reducing or eliminating Defense industrial waste streams through aggressive pollution prevention.

Legislation

SERDP Mission

As our defense posture adjusted to new requirements in the early 1990's, the Congress established the Strategic Environmental Research and Development Program (SERDP) in Public Law 101-510 (Title 10, U.S.C., §§2901-2904) as a DoD program planned and executed in partnership with DOE and the Environmental Protection Agency (EPA).

SERDP MISSION
(1) Address environmental matters of concern to the DoD and the DOE through support for basic and applied research and development of technologies that can enhance the capabilities of the departments to meet their environmental obligations; (2) Identify research, technologies, and other information developed by the DoD and the DOE for national defense purposes that would be useful to governmental and private organizations involved in the development of energy technologies and of technologies to address environmental restoration, waste minimization, hazardous waste substitution, and other environmental concerns, and to share such research, technologies, and other information with such governmental and private organizations; (3) Furnish other governmental organizations and private organizations with data, enhanced data collection capabilities, and enhanced analytical capabilities for use by such organizations in the conduct of environmental research; and (4) Identify technologies developed by the private sector that are useful for DoD and DOE defense activities concerning environmental restoration, hazardous and solid waste minimization and prevention, hazardous material substitution, and provide for the use of such technologies in the conduct of such activities.

FY 1996 Changes

While the basic statute and congressional intent have remained the same since 1991, several recent changes have impacted SERDP management. Legislative changes in the FY 1996 Defense Authorization Act included the following:

- Modify the Council membership, specifically;
  - Army, Navy, Air Force, and US Coast Guard, previously advisory members, became voting members of the SERDP Council.
  - The Assistant Secretary of the Air Force for Space was removed from the SERDP Council.
- Adjust the annual reporting requirements;
  - Guidance for the annual report regarding the need to address the current year's activities and plans for next year remains the same, however, requirements to include specific information, such as funding distribution to the laboratories, changes to military specifications, and other similar details were eliminated.
  - The annual requirement to submit a five-year strategic plan to Congress was deleted.

Program Goals

SERDP's goals, as prescribed by the SERDP Council, are to:

- Resolve environmental concerns in ways that enhance military operations, improve military systems' effectiveness, and help ensure the safety of personnel; and
- Support technology and process development that reduce operational and life-cycle costs, including those associated with environmental cleanup and costs of full compliance with environmental laws and regulations.

In the course of addressing DoD's highest priority environmental needs in the areas of Cleanup, Compliance, Conservation, and Pollution Prevention, SERDP has also sought opportunities to help solve other significant national and international environmental problems through the application of DoD's technical capabilities, analytical systems, and information.

SERDP goals have been achieved through:

- Identifying and supporting programs of basic and applied research and development to;
  - facilitate environmental compliance, remediation, and conservation activities,
  - minimize waste generation, including reduction at the source, and
  - substitute use of non-hazardous, non-toxic, non-polluting, and other environmentally sound materials, substances, and processes;

- Promoting the effective exchange of information regarding environmentally related research and development activities;
- Ensuring that SERDP research and development (R&D) activities complement, but do not duplicate, Tri-Service R&D programs and other ongoing activities;
- Providing appropriate access to data under the control of, or otherwise available to, the Departments of Defense and Energy that is relevant to environmental matters;
- Facilitating the transfer of unclassified DoD and DOE environmental information and technology to other sectors of society which might be able to use them to forward national environmental objectives; and
- Emphasizing multi-service, inter-departmental research and development projects and using the unique capabilities of the partnering Federal agencies, private industry, and academia to solve the Departments' environmental problems.

Program Technical Strategy

SERDP has and will continue to pursue six avenues in planning and executing defense mission-relevant environmental R&D:

- Identify and fund major-impact, multi-agency environmental R&D programs to solve high-priority, mission readiness related concerns of DoD;
- Identify opportunities to accelerate existing DoD environmental quality R&D programs, and fund those that address the priority concerns of the Department;
- Identify, leverage, adapt, and/or adopt existing technologies to address environmental concerns of DoD and DOE;
- Advance and use applicable state-of-the-art modeling and simulation capabilities to accomplish SERDP goals;
- Use the technical and research capabilities of the SERDP partners, including their unique data collection and analysis capabilities, as appropriate;
- Plan for a transition of successfully proven technologies to demonstration and validation or to commercialization and implementation.

Research Framework

In executing this strategy, SERDP will focus on the existing four Thrust Areas in the DoD's Tri-Service Environmental Quality R&D Strategic Plan - Cleanup, Compliance, Conservation, and Pollution Prevention.

Figure I-1 provides the SERDP research taxonomy to be used in FY 1997 to define the SERDP Program. As the DoD's corporate environmental R&D program, the SERDP primary Thrust Areas are a result of the user community needs for science and technology required to accomplish the military mission in an environmentally compliant manner. Accordingly, these Thrust Areas are consistent with the focus of the Office of the Deputy Under Secretary of Defense for Environmental Security - Cleanup, Compliance, Conservation and Pollution Prevention - and they directly parallel the four 'pillars' of the Tri-Service Environmental Quality Technology programs. The Thrust Areas also correspond to those identified in the National Environmental Technology Strategy.

CLEANUP	COMPLIANCE	CONSERVATION	POLLUTION PREVENTION
• Site Characterization and Monitoring	• Air	• Maintain/Enhance Training/Testing Capability	• Air
• Remediation Technologies	• Water	• Natural Resource Stewardship	• Water
• Risk Assessment Technologies	• Solid	• Cultural Resource Stewardship	• Solid
	• Noise		• Modeling & Databases

Figure I-1. Research Areas

The SERDP leverages and interacts with other environmental programs to identify and solve defense specific needs, extend applications of defense information to others, and build on existing science and technology to derive more useable and cost-effective approaches for achieving reductions in environmental risks. The efforts collectively facilitate acceptance by Defense Systems Program Executive Officers (PEOs) and transition to the commercial sector. **Figure I-2** illustrates SERDP's role in the technology development process.

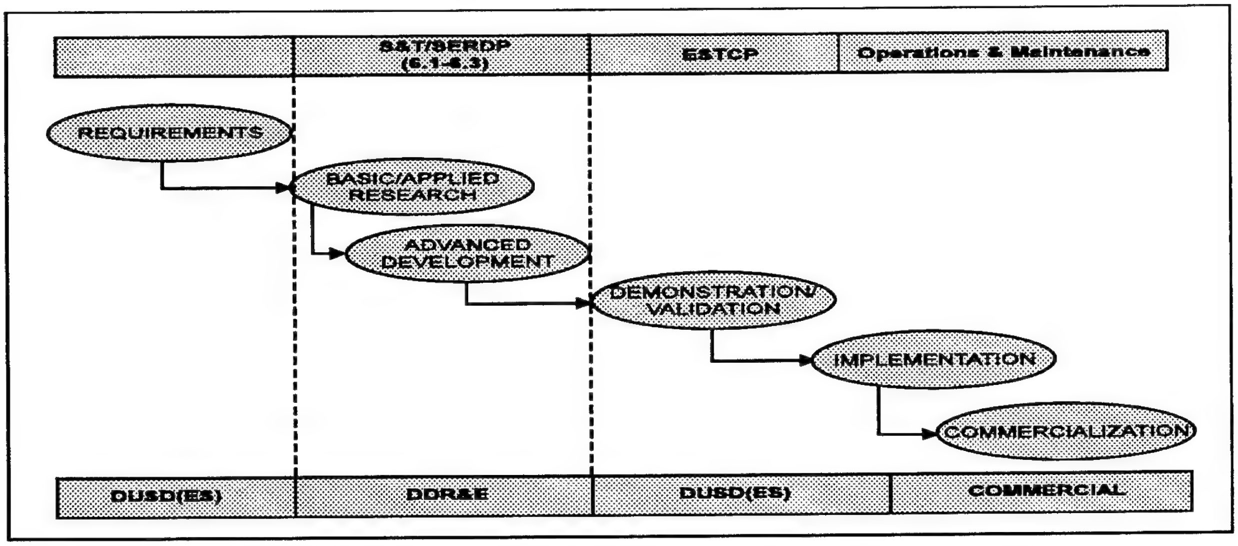

Figure I-2. Environmental Technology Development Process

Throughout the year, and as a matter of routine, SERDP has interacted with program participants to effect information transfer regarding the capabilities and ongoing programs that are relevant to SERDP activities. Typical interactions included:

- Briefings to the Scientific Advisory Board from DOE, EPA, and ESTCP managers;
- Project briefings to SERDP management;
- Staff attendance at the annual DoD Environmental Technology Area Review & Assessment (TARA) review; and
- Staff participation in environmentally related conferences and workshops.

One of the strengths of SERDP is the multi-agency management and oversight of the program. Membership of the SERDP Council, Executive Working Group, and Technology Thrust Area Working Groups consists of programmatic and technical individuals that represent the three primary participating organizations. This arrangement brings a breadth of knowledge and experience to the table at several levels of management and significantly lends credibility to the program.

Individuals that are knowledgeable regarding DOE's Environmental Management technology development programs and EPA's SITE projects are represented at the same table along with the principal representative of the defense user community. Similarly, many of the DoD representatives on the TTAWGs also serve on the DoD Joint Engineers Management Panel

team and provide insight to the technology roadmaps being planned within DoD Reliance agreements. Collectively, these mutual benefits result in a well-coordinated, leveraged program that reduces duplication of effort within the Federal R&D infrastructure.

Investment Strategy

The SERDP Council annually determines the distribution of funding to the Thrust Areas that generally follows a set of investment patterns or funding trends within each Thrust Area. **Figure I-3** conceptually depicts the anticipated relative funding trends in each of the technology Thrust Areas. Forecasts are based on known or expected requirements and stated goals of the Services and ODUSD(ES). Requirements for R&D may change from year to year, and, consequently, these trends may not reflect actual investments.

DoD has set specific Cleanup goals for completion in the future. Accordingly, in order to impact these goals, near term new starts or technologies currently under development must be delivered to the field in the near future. Hence, the investment in Cleanup is expected to decrease over the next five years. This is part of the conscientious shift from a cleanup posture to that of preventing pollution within the DoD.

A focused investment to eliminate future waste streams will sharply reduce or preclude the environmental consequences experienced in the past. Clearly the biggest returns in the future are in reducing or eliminating the generation of pollutants. An increase in Pollution Prevention technology investment is anticipated over the next five years.

Current environmental regulations often preclude, or severely restrict, military training, operations, and manufacturing activities, if they are not in total compliance. The current regulatory environment indicates a possible decrease in environmental legislation. A commensurate slight decrease in SERDP's Compliance investment is anticipated; however, this could change with a reinvigorated environmental regulatory congressional agenda.

Conservation technologies have the potential to have the greatest impact on the readiness of military units. Research results from this area will help to resolve legal stalemates and promote environmentally sound land use management. Accordingly, investments in Conservation efforts are anticipated to increase as research efforts mature to demonstration.

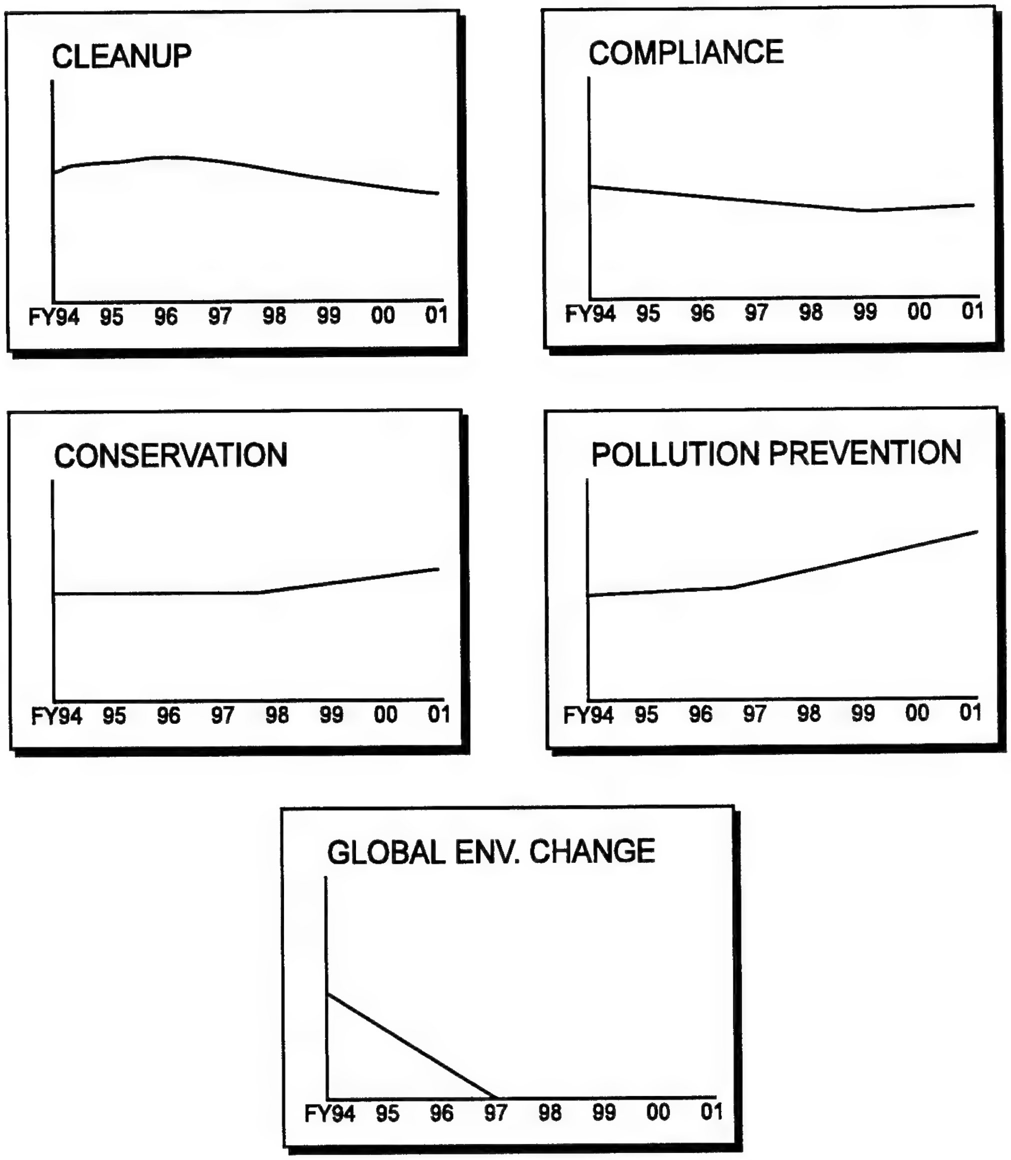

Figure I-3. Balance Across the SERDP Thrust Areas

Program Management and Oversight

Council Actions

In FY 1996, SERDP institutionalized the four Keys to SERDP Success which are to:

- Address the highest priority, defense mission-relevant environmental requirements with a sharper focus on multi-service issues;
- Ensure that world-class researchers are planning and performing the research;
- Aggressively transfer SERDP results to the users and/or the next steps of development, demonstration, or commercialization; and
- Ensure sound fiscal management.

These Keys have become the hallmark of SERDP's success and are the basic metrics to measure all of SERDP's program management activities completed in FY 1996 and its plans for FY 1997.

On August 29, 1995, the SERDP Council approved the FY 1996 Program Plan and the FY 1997 Strategic Guidance which sharply refocused the Program to address the highest priority, Defense mission-relevant environmental requirements in the four major DoD environmental thrust areas of Cleanup, Compliance, Conservation, and Pollution Prevention (C3P2) as defined by the Deputy Under Secretary of Defense for Environmental Security. Other significant changes to the FY 1997 Strategic Guidance included:

- The use of applicable remote sensing and energy technologies to achieve C3P2 goals;
- The advancement and use of state-of-the-art modeling and simulation to accomplish SERDP goals;
- Expeditiously transitioning proven technologies to demonstration/validation (Dem/Val);
- A move toward a risk-based approach to Cleanup;
- Focusing on Ecosystem Management for Conservation; and
- Continuing to shift emphasis from Cleanup to Pollution Prevention.

The SERDP FY 1996 appropriation decreased slightly from the FY 1995 levels ($61.9 million to $58.1 million). Consistent with the intent of the FY 1996 Strategic Guidance, the SERDP Council directed further reductions in the Energy Conservation/Renewable Resources and Global Environmental Change Technology Thrust Areas. Consequently, projects in those technology thrusts were completed in FY 1996 and were transitioned to appropriate Federal Departments. The remainder of the Program was proportionately reduced with critical mass maintained on the highest priority projects and new starts maintained at the proposed funding level.

Of critical importance at this juncture, the SERDP Program Office continued to accelerate the Program schedule which resulted in the release of the FY 1996 Program funding on budget cycle for the first time in SERDP's history. Timely release of Program funds to participants, coupled with emphasis on the Keys to Success, promoted sound technical progress and fiscal execution.

On September 19, 1996, the SERDP Council met to approve the FY 1997 Program and the FY 1998 Strategic Guidance. In remarks to the SERDP Council at this meeting, Dr. Walter J. Weber Jr., Director of the Great Lakes and Mid-Atlantic Center for Hazardous Substance Research, University of Michigan, and Chair of the Scientific Advisory Board (SAB), shared his thoughts on SERDP's progress during the year. Dr. Weber stated that the SAB members strongly endorse the 1997 Program and support SERDP for its direction to focus projects on Defense needs. He provided examples of significant projects having multi-service/multi-agency, defense mission applications, and he identified several unfunded, high priority, Defense environmental requirements. Dr. Weber recommended gradual program growth for future investment by the SERDP Council. In sum, Dr. Weber reiterated the SAB's endorsement for SERDP and was confident that SERDP is meeting the intent, goals, and objectives of Congress.

With this endorsement, the Council supported a balanced 1997 program in the four Defense environmental thrust areas and authorized the SERDP Executive Director to modify the program in accordance with the final funding level. No significant changes to the FY 1998 Strategic Guidance resulted.

The SERDP FY 1997 appropriation decreased slightly from FY 1996 levels to $54.88 million. However, at the Council's direction, critical mass was maintained on the highest priority projects with all new starts kept intact. SERDP released FY 1997 Program funding on budget cycle.

As their final action of the year, the Council approved the FY 1998 SERDP Investment Strategy. The Council directed the Executive Director to view the program build from the perspective of: how the SERDP integrates itself with the national effort, preclude duplication of research efforts, leverage other environmental programs, and continue to strive for congruency with the Administration's goals. To help institute this, the Council embraced a recommendation from their Executive Working Group (EWG) to further strive for program

quality by instituting a formal independent, external peer review process for the review of the FY 1998 proposals. This would serve as a trial period with the expectation that, if successful, it would be institutionalized.

Subsequent to this direction, Dr. Anita Jones, Council Chair, suggested that the time had come to further enhance technical excellence, innovation, and a leaning toward high-risk/high-payoff projects. Accordingly, the Executive Working Group embarked on developing a plan to solicit FY 1998 proposals from industry, academia, and the not-for-profit sector. SERDP has issued a Broad Agency Announcement under sponsorship of the Office of Naval Research that requests proposals seeking innovative technological approaches for solving some of the department's most pressing environmental problems. These proposals will be evaluated along with the best proposals submitted from the Federal laboratories. To promote a 'level playing field', SERDP has embarked on a Program-wide external peer review of all FY 1998.

The SERDP Council anticipates final review and approval of the FY 1998 Program and FY 1999 Strategic Guidance in September 1997.

Executive Director Actions

Keys to Success

In compliance with the Council's guidance, the SERDP Executive Director planned FY 1996 activities by continuing to sharply focus on the four key metrics in order to facilitate success of the Program. He aggressively addressed each item.

Address the highest priority, defense mission-relevant environmental requirements with a sharper focus on multi-service issues.

The Executive Director and his Program Managers worked hand-in-hand with the Office of the Deputy Under Secretary of Defense for Environmental Security (ODUSD(ES)) to establish clear lines of communication, address effectively the Department's highest priority environmental requirements, and foster transition of technical efforts to field demonstration or implementation. Through the use of tailored Statements of Need (SON), the Executive Director solicited cooperatively funded and executed projects to address high priority multi-service needs. The Technology Thrust Area Working Groups (TTAWG), SERDP's multi-agency planning and coordinating bodies, facilitated this process through effective communications and applying their knowledge of the needs and capabilities of the Federal R&D infrastructure.

Ensure that world-class researchers are planning and performing the research.

Increased emphasis was placed on ensuring that the credentials of the Principal Investigator (PI) and associate performers on the project represented the top of the class. World-class research is considered the cornerstone of SERDP projects, and the SAB, TTAWGs and the Executive Director all ensure that the research team demonstrates the highest standards of research and superior technical merit.

Aggressively transfer SERDP results to the users and/or the next steps of development, demonstration, or commercialization.

During the annual In-Progress Reviews in May 1996, the PIs of all 98 projects were required to demonstrate their interaction with the user community or those who will sponsor further development. In attendance were all members of the multi-agency TTAWGs, members from the Joint Engineers Management Panel (JEMP) team, and key representatives from ODUSD(ES), including the Program Managers for the Environmental Security Technology Certification Program (ESTCP) and the Legacy Program. SERDP also implemented several technology transfer initiatives at the Program level to further complement the efforts of each project PI in the movement of their technology to the field or higher category development. Further detail on this subject follows in the next section.

Comply with current DoD fiscal guidance.

The health of every project's fiscal status became a primary metric during FY 1996. Through continuous monitoring, the SERDP Executive Director was able to continue to accelerate the program development schedule in order to release the FY 1996 Program appropriation on budget cycle for the first time in the history of SERDP. Through the continuous monitoring of a project's technical and fiscal performance, the Executive Director is able to take aggressive, corrective action to promote effective use of scarce R&D resources.

Several other activities were completed in 1996 that deserve mention:

- SERDP installed a new management reporting system that provides research investigators with a tool which is more responsive to Program needs. This tool, the Automated Information System, allows each Principal Investigator to report technical and fiscal progress of his/her project via the Internet. It also serves as a project management tool.

- The SERDP Executive Director convened a special review of the National Environmental Technology Test Sites (NETTS) Program. As a result of this review, he implemented stronger oversight/management of NETTS and instituted standards for the selection, conduct, and data collection for all projects to be conducted at these sites.

Technology Transfer

SERDP is completing its fifth year of technology development. Accordingly, many of the projects initiated in the earlier years are being completed and are now ready for implementation or transition to the next step of development. SERDP has taken aggressive steps to facilitate this transfer.

Transfer of technology, from research to the DoD environmental user community, is a key objective of the entire SERDP. This overall program objective is achieved by supporting applied research and technology demonstrations that respond directly to high priority DoD mission related environmental needs.

SERDP management has taken significant steps to facilitate and enhance information transfer. A formal SERDP display was developed and exhibited at several national conferences including Superfund VIII, the annual American Defense Preparedness Association (ADPA) Environmental Conference, the Tri-Service Environmental Technology Conference, and the ADPA Joint Service Pollution Prevention Conference. With fact sheets prepared on the accomplishments of each of SERDP's four Thrust Areas and a general brochure to inform attendees, SERDP took an active role in increasing awareness of the Program's attributes, objectives and accomplishments in the environmental community.

SERDP planned, coordinated, and held its second annual Symposium from November 20-22, 1996, in Washington, D.C. - a technical exposition that attracted nearly 400 attendees to hear keynote policy addresses and 63 technical presentations and to view 91 exhibits - all of which provided an outstanding forum to exchange the latest defense mission-relevant, environmental technology information and ideas. Planning for the next symposium is well underway.

The SERDP Quarterly Information Bulletin increased distribution to over 4,000 people at all levels of the private and governmental sectors. The Bulletin featured SERDP accomplishments, articles on SERDP initiatives, and highlights of Program development issues. A complete listing of SERDP products were included in the January 1996 Bulletin to ensure that the entire readership is aware of all available SERDP results including reports, papers, videos, and other publications. Henceforth, this listing will be available on the SERDP Home Page.

The SERDP Home Page (http://www.hgl.com/serdp/) allows users of the Internet to become familiar with SERDP goals and objectives, technical areas of interest, planning calendars, performers, management structure, and program results. The SERDP Home Page was placed on the Internet World Wide Web in 1995 and was showcased at the first SERDP Symposium in April 1995. In 1996, it has provided a broader distribution of Program information. Recent additions include providing technology area summary data, a list of

SERDP performers with associated hypertext information links to describe the work being performed at various locations, and statements of need for the FY 1998 call for proposals.

Management Plans for FY 1997

After almost three years as the Executive Director, Dr. John Harrison departed for his assignment at the Waterways Experiment Station. SERDP's new Executive Director is Mr. Bradley P. Smith, formerly the Assistant for Environmental Science within the Office of the Director, Defense Research and Engineering.

Major SERDP events planned for FY 1997 include:

- Initiate direct private sector participation via Broad Agency Announcements for the solicitation of FY 1998 proposals;
- Implement a pilot external peer review program for evaluating FY 1998 proposals received from both the Federal and private sectors;
- Conduct the annual In-Progress Reviews, focusing on technical progress, technology transfer plans and fiscal management;
- Conduct a workshop on Large-Scale Ecological Management designed to develop a research strategy to address large-scale, applied ecosystem management problems of the Departments of Defense and Energy; and
- Conduct the annual Symposium to further focus on technology transfer.

Summary

SERDP has had a productive year and plans to continue to expand the focus on transferring SERDP research products to users. Notwithstanding budget pressures, SERDP has maintained focus on the highest priority defense environmental needs and program quality. FY 1997 and FY 1998 are anticipated to be a special period for SERDP; direct participation of the private sector may pay great dividends in technology development and transfer. Continued attention to the four SERDP Keys to Success and support from the Congress will assure forward movement to provide an enhanced, efficient capability to address this nation's environmental concerns.

II. SIGNIFICANT ACCOMPLISHMENTS

Introduction

Since its inception in 1991, SERDP has supported over 200 environmental science and technology projects that are providing operational savings or cost avoidance to meet DoD's environmental obligations in a cost-effective manner.

Approximately 70 percent of all SERDP funds address proof-of-concept projects (applied or exploratory research), taking fundamental scientific principles and applying them to critical environmental situations. The remainder of the program focuses on demonstrating successfully developed technologies in proof-of-principle field tests at a prototype scale (advanced development). At this stage, SERDP seeks to minimize the risks of further development and initiate acceptance in the regulatory community.

One of the unique discriminators of SERDP is that it promotes direct competition between top scientists and engineers in the intramural Federal laboratory system, the industrial sector, and the academic arena to develop solutions, processes, and prototypes. To stimulate world-class research, SERDP encourages cooperative developments between these sectors and promotes technology transfer and information exchange.

A number of SERDP's most significant accomplishments during the past two years are described below. While these projects represent just a small selection of the many innovative and ground breaking projects supported by SERDP, they illustrate the breath and depth of the Program. Furthermore, these accomplishments demonstrate the potential enormous cost savings that will be realized when new technologies become fully implemented.

Cleanup Accomplishments

Research and Development Strategy for Unexploded Ordnance Detection

Under direction from Congress, the U.S. Army in 1994 conducted an evaluation of available unexploded ordnance (UXO) detection technologies at the Jefferson Proving Ground in Madison, Indiana. These field tests provided an unbiased ranking of current technology performance in the field, but also revealed serious shortcomings, including a large percentage of "false alarms" due to a lack of discrimination capability from background/clutter effects and interferences. The tests did not provide a scientific analysis of why particular systems did or did not perform well.

In response to the recognized deficiencies of current UXO detection technologies, and in order to provide a sound scientific basis for future technology development, SERDP in

FY 1996 funded the Massachusetts Institute of Technology (MIT) Lincoln Laboratory to assist in defining basic and applied research needs in the area of UXO detection. Lincoln Lab scientists conducted a comprehensive analysis of the scientific and technical state-of-the-art for UXO detection and identification to identify critical issues and develop recommendations for an integrated research and development strategy to meet identified DoD needs. The study concluded that the best approach to addressing the UXO sensing problem is to develop multiple sensor systems, and that such development should be done in accordance with an overall system approach, with research focusing on phenomenological investigations that specifically address the unique characteristics of UXO detection by highly improved single sensors which are integrated through advanced datafusion algorithms to provide multi-sensor capability.

The strategy is being implemented by SERDP with one new start project in FY 1996, two new start efforts in FY 1997 and a specific call for proposals for funding in FY 1998.

National Environmental Technology Test Site (NETTS) - Dover Air Force Base

In order to facilitate the transfer of cleanup technologies to full-scale use, SERDP has provided dedicated field test and demonstration facilities by establishing the National Environmental Technology Test Site (NETTS) Program in FY 1993. NETTS provides permitted, well-characterized test sites at five former or currently operational DoD facilities to accommodate demonstrations for high priority contaminants in a variety of environmental settings. The five NETTS sites are located at Dover Air Force Base (AFB), DE; Volunteer Army Ammunition Plant, TN; Naval Construction Battalion Center, Port Hueneme, CA; McLellan AFB, CA; and the former Wurtsmith AFB, MI.

SERDP and Air Force, Armstrong Laboratory have established the Groundwater Remediation Field Laboratory (GRFL) at the Dover AFB National Test Site. The Dover site focuses on contained release field tests for volatile organic compounds (VOCs), dense non-aqueous phase liquids (DNAPLs), and permeable reactive walls for chlorinated solvents The GRFL is the only facility in the U.S. permitted to conduct contained releases of DNAPLs into a previously non-impacted water table aquifer. The GRFL began operations on May 31, 1996 with the first release experiment. This first experiment is a joint effort with the Rice University's DoD-sponsored Advanced Applied Technology Demonstration Facility (AATDF) on application of bioventing of fuels and chlorinated solvents. Ongoing and future work at the GRFL includes three new SERDP field demonstration experiments on aquifer restoration of DNAPL-contaminated sources, permeable barrier for treating chlorinated solvents, and bio-enhanced in-well stripping for treating TCE, supporting both the public and private research sectors such as the EPA Remediation Technology Development Forum (RTDF). Participants in research at the GRFL total over 30 different government organizations, private companies, and universities

In October 1996, The US EPA Region III Administrator, awarded the SERDP Executive Director and Deputy Director, the GRFL, Dover AFB, and the Delaware Department of Natural Resources and Environmental Control, with special recognition awards for the initiative taken in establishing the GRFL research facility.

Mobile Underwater Debris Survey System (MUDSS)

Removal of Unexploded Ordnance (UXO) is DoD's highest cleanup priority. Included in this requirement is a critical need to develop a fieldable multi-sensor system to detect and quantify the extent of underwater unexploded ordnance (UXO) at formerly used defense sites (FUDS). The traditional method for surveying underwater UXO sites is by divers which is slow, costly and exposes the personnel to significant risks.

Leveraging with the Navy's and NASA's R&D dollars, SERDP has supported the development of the multi-sensor (three sonars, an electro-optic sensor, a chemical sensor, and a magnetic gradiometer) MUDSS. The goal of the MUDSS project is to demonstrate the technologies necessary for underwater surveys of shallow water inland and coastal sites littered with UXO. A successful demonstration will prove the system concept for finding and mapping the locations of UXO ranging from small shells to large bombs in water depths between four and 100 feet. These technologies then can be applied to the environmental cleanup of underwater UXO at scores of FUDS. MUDSS marries minehunting technologies from Coastal Systems Station (CSS) with data fusion and visualization technologies developed for NASA by the Jet Propulsion Laboratory (JPL). Included is an assessment of chemical sensor technology development by JPL for the FAA. Each MUDSS sensor outperforms any commercial off-the-shelf (COTS) sensor, and the final integrated MUDSS system will be able to provide underwater UXO detection capability far exceeding any COTS system (including detecting buried UXO). The development cost of the system has been minimized by utilizing hardware and software components from parallel Navy and NASA programs. Approximately 140 feasibility test runs in shallow water have detected inert UXO ranging in size and shape from 60 mm mortars to 2000 lb. bombs. The Army Corps of Engineers has the current mission for munitions remediation and cleanup for over 900 FUDS and has strongly endorsed the transition of MUDSS to an operational capability. Use of MUDSS as compared to manual survey can reduce survey time by a factor of five and reduce costs by 50-70 percent, which translates into a savings of up to $400K per square nautical mile.

Site Characterization and Analysis Penetrometer System (SCAPS)

DoD and DOE have owned and operated thousands of installations, ranging from training and testing bases to industrial production facilities, for a very long time. Many, if not all of these installations include sites that have become contaminated and may require environmental cleanup.

Traditional methods of characterizing contaminant sites incorporate drilling, sampling, and off-site laboratory analysis, which are costly and time consuming. It is estimated that costs for site investigations could be reduced by at least 50 percent for every contaminant for which a reliable in-situ chemical sensor is available. Funded in part by SERDP, SCAPS has shown the capability to screen contaminated sites rapidly. SCAPS combines traditional cone penetrometer testing (CPT) technology with chemical sensors to screen sites rapidly and cost-effectively for the presence of subsurface environmental contaminants. The SCAPS platform consists of a 20-ton truck equipped with hydraulic rams that are capable of pushing instrumented probes to a maximum depth of 50 meters. The probes collect geophysical (soil stratigraphy) and contaminant data which are acquired, recorded, processed, and visualized by means of onboard computers. Initially, the SCAPS trucks were fielded with laser induced fluorescence (LIF) probes for detecting POL contaminants. The LIF probes are capable of collecting soil stratigraphy and POL data with approximately 2-cm spatial resolution, which are used to develop three-dimensional visualizations of the contaminant plume. Under SERDP sponsorship, the SCAPS capabilities have been enhanced significantly by the development and fielding of improved sensors. SERDP continues to fund the accelerated development of additional sensors for SCAPS, including sensors to detect explosive compounds, solvents, and heavy metals. SCAPS technology has been demonstrated to reduce the costs of traditional site screening by up to 90 percent; it saved $1M at one site alone. This technology has been patented and licensed to commercial firms in the US and Europe and is presently fielded by the DoD and DOE.

Trichloroethylene (TCE) Risk Assessment

TCE is among the top ten priority groundwater contaminants within the DoD and nationally, and is present at over 39 percent of Superfund sites, primarily as a result of its industrial use as a degreaser. The current TCE maximum contaminant level for drinking water is quite stringent (5 parts per billion) and cleanup of all TCE contaminated groundwater at DoD sites to this level would result in compliance costs estimated at billions of dollar. Current EPA-promulgated drinking water standards are based on toxicological information collected in the 1970s and 1980s and on a risk assessment paradigm which includes significant policy-driven assumptions and safety factors. This leads to substantial uncertainty regarding the correlation between the cleanup level and cost-effective protection of human health.

With funding from SERDP and the U.S. Air Force, this project has provided EPA with rigorous scientific data and methodologies which replaces non-scientific policy assumptions with science-based evaluation. The major scientific contribution resulting from SERDP funding of this project is the development of state-of-the-art methodology and supporting data for extrapolation of toxicological findings in rodents to humans. In vitro metabolism studies were conducted with livers from accident victims and compared to rodents. Second generation physiologically-based pharmacokinetic dosimetry models were developed and validated for experimental animals and humans. Critical data were collected supporting hypotheses about mode of actions for the observed kidney and liver tumors found in experimental animals exposed to TCE. Results from this project have played an instrumental role in the US EPA's recent decision to give TCE "Flagship" status. The US EPA is now conducting a formal scientific reevaluation of the cancer and noncancer potency of TCE. A consequence of this reevaluation may be the relaxation of the TCE standard which would result in significant savings in the cleanup of TCE contaminated groundwater

Compliance Accomplishments

Lead-Based Paint Hazard Mitigation

DoD owns 1.2 billion square feet of housing and 200 million square feet of structures containing lead-based paint (LBP). The cost of LBP hazard mitigation of DoD facilities is expected to be approximately $1 billion over 10 years. Additional environmental compliance requirements potentially could increase this cost of LBP removal.

Funded by SERDP, researchers at the US Army Construction Engineering Research Laboratory (CERL) have developed a thermal spray vitrification process that removes and encapsulates LBP. The technology involves spraying a molten iron borosilicate glass spray onto the surface to be treated. The lead is absorbed into the glass and thermal (cooling) stresses cause the glass to crack and crumble off the surface while encapsulating the lead paint. A related technology developed under this SERDP project uses a microwave-assisted paint stripping process for the removal of lead-based paint from wood structures. Together these technologies will result in a 30 to 40 percent cost savings in LBP removal operations. A successful field test of the thermal spray vitrification process was conducted in November 1995. Two US patents have been awarded for technologies developed with SERDP funding ("Removal of Lead-Based Coatings by Vitrification" and "Microwave Assisted Paint Stripping"), and two US patents have been filed ("Vitrification and Removal of Coatings Containing Hazardous Material" and "Ceramic Reinforced Glass Enamel for Bonding to Metal"). Tri-Service documents produced as a result of this SERDP-sponsored project include those for procurement and design, specifically guide specifications, technical manuals, and user guides. Technology demonstrations are scheduled at four DoD sites.

Characterizing Open Burning/Open Detonation (OB/OD) Emissions

Substantial amounts of obsolete munitions and other energetic materials have become an increasing burden on the military logistics system. A substantial proportion of energetic materials already are being reused and recycled, and DoD is actively developing new manufacturing techniques to promote recycling. However, OB/OD remains the only economically feasible option for about 50 percent of the demilitarization inventory. Due to concerns over health and other environmental risks of OB/OD, permitting requirements have become increasingly stringent, and the US EPA has begun closing OB/OD operations (e.g., Ellsworth Air Force Base, SD).

To respond to the need for better ways to characterize emissions and obtain the required permitting data, SERDP has provided funding to researchers at the U.S. Army Dugway Proving Ground, UT, to technologically expand testing facilities, instruments, and procedures. This project has developed a unique Bang Box testing chamber which allows the characterization of emissions of complete munitions containing up to 45 kg of high explosive. The experimental effort is executed in cooperation with researchers at the US EPA's National Exposure Research Laboratory (NERL) who, through a separately funded SERDP effort, are developing an atmospheric pollution transport and dispersion model to predict accurately how the emission for OB/OD operations will disperse in the environment. Collectively, these SERDP projects are providing DoD and DOE the tools to acquire the information needed to obtain RCRA permits for OB/OD activities, while ensuring that the health of humans and ecosystems is protected at all times.

Conservation Accomplishments

Marine Mammal Acoustic Tracking System (MMATS)

In order to achieve its mission requirements of naval exercise training and testing, the U.S. Navy needs to perform ship shock tests while still complying with the National Environmental Policy Act (NEPA), the Endangered Species Act (ESA), and the Marine Mammal Protection Act (MMPA).

In response to this high-priority requirement, SERDP funded the Naval Research and Development Activity in San Diego, California, to develop the MMATS. MMATS provides a field of up to ten sonobuoys deployed by aircraft and a neural net detection and tracking system mounted inside the aircraft. By listening to the "songs" of the whales, the system can detect, differentiate by species, and track blue, fin, humpback, and sperm whales. In the spring of 1994, MMATS technology was used to resolve a court injunction against the Navy brought by the Natural Resources Defense Council regarding ship shock tests of the USS

JOHN PAUL JONES. The tests involved detonating a number of 10,000-lb explosive charges at increasingly close ranges to the vessel in order to evaluate the performance of shipboard systems under simulated battlefield conditions. Costs associated with the delay were estimated to be $150,000 per week. The injunction was lifted only when the Navy demonstrated MMATS' ability to detect and warn shock test organizers of whales approaching within two miles of the test site. As a requirement for lifting the injunction, the court stipulated that MMATS must be used during the tests. MMATS performed superbly, on three occasions delaying a detonation until a blue whale had cleared the area. The SERDP-supported MMATS technology thus played a crucial role in avoiding the cancellation of a $34M testing effort while at the same time ensuring whale safety. MMATS is now a fully operational technology and is being used Navy-wide in all ship shock tests.

Pollution Prevention Accomplishments

Non-Ozone Depleting Refrigerants for Navy Chillers

The Navy is a large user of CFC-114, a stratospheric ozone-depleting refrigerant used in shipboard chillers for purposes of vital equipment cooling and comfort air-conditioning. Approximately 500 lbs of refrigerant are used in a 125 ton shipboard chiller. Effective December 31, 1995, production of CFCs ceased under current national policy and international agreements. Therefore, the Navy was faced with a major challenge in finding a CFC-114 replacement which met environmental and performance criteria. Two available options for the Navy were either to find a suitable alternative refrigerant for retrofitting CFC-114 chillers or to replace the entire surface and submarine fleet's 800 chillers with completely different cooling plants.

Under partial SERDP sponsorship, the Naval Sea Systems Command and EPA's Air Pollution Prevention and Control Division (APPCD) conducted cooperative efforts to evaluate EPA's proposed HFC-236ea and HFC-236fa as alternatives to CFC-114 used as the refrigerant for the Navy chillers. The APPCD's initial laboratory testing and computer modeling of refrigeration performance at the National Risk Management Research Laboratory, Cincinnati, OH, determined that HFC-236ea and HFC-236fa closely matched the performance of CFC-114 in the Navy's shipboard chillers. Under SERDP sponsorship full-scale testing in chillers was conducted at the Naval Surface Warfare Center's facility in Annapolis, Maryland. Additionally, EPA performed the heat transfer performance and toxicity tests. Based on the extensive test results, the Navy selected HFC-236fa to replace CFC-114 for its surface fleet. HFC-236fa received approval through EPA's SNAP (Significant National Alternatives Policy) program and PMN (Premanufacturing Notification) review process for commercial production. In April 1996, an EPA press release announced the Navy's decision to retrofit surface ship chillers with HFC-236fa.

Current estimates for a new chiller unit with HFC-236fa are $875K excluding installation costs, and conversion costs for existing CFC-114 chillers to HFC-236fa would be approximately $300K per unit. Thus, retrofitting the entire surface fleet of about 550 CFC-114 shipboard chillers to accept HFC-236fa will save the Navy over $300M.

Laser Ignition System for DoD Guns

Three hundred and seventy five tons of primer and ignitor material are used by DoD each year for artillery rounds. Hazardous materials used in, and during production of, chemical primers and ignitors include lead styphnate and volatile organic compounds (VOCs). Hazardous wastes also are generated during demilitarization.

Under partial sponsorship of SERDP, the US Army Research Laboratory, the Army's Armaments Research, Development and Engineering Center (ARDEC) and the Army's Benet Laboratories have developed a laser ignition system (LIS) for DoD guns which utilizes light to completely eliminate chemical ordnance ignition materials. A LIS has the additional advantage of providing significant increased rates of fire and soldier protection. When the shelf life of the rounds has expired, their demilitarization will also be easier to accomplish in an environmentally sound manner. In addition, the hazards associated with the storage and transport of the primer and ignitor material is eliminated. The LIS system has been adopted for the Crusader self-propelled 155mm howitzer, and has been demonstrated successfully on the Paladin self-propelled howitzers and the Apache 30 mm automatic cannons. It is estimated that $6M/year in savings will be realized from the use of this system for large and medium caliber ammunition alone. Cooperation with private industry through the Small Business Innovative Research Program (SBIR) has provided significant leveraged funding for SERDP investments, and is providing an effective avenue to develop commercial applications of the dual use electro-optic technology. Among others, laser ignition technology has been incorporated in the "Jaws of Life" cutters used by FEMA in rescue operations following the Oklahoma City bombing. This application of the LIS technology has won a Presidential Award under the Technology Reinvestment Program. The technology is a finalist (top 6 percent) for the prestigious "1996 Innovations in American Government" sponsored by Harvard University JFK School of Government.

Clean, Agile Manufacturing of Energetics (CAME)

Approximately 100 million pounds of energetic materials [propellants, explosives, and pyrotechnics (PEP)] are produced each year for DoD, DOE, and NASA as main charge explosives, rocket propellants, and flares/illuminators. PEP chemicals and products are produced in government operated, government owned - contractor operated (GOCO), and defense contractor facilities. Ever stricter environmental regulations and waste restrictions are curtailing production of some PEP chemicals. Additionally, under Executive Order 12856,

Federal facilities are required to achieve a 50 percent reduction of hazardous wastes by 1999 using 1994 as a baseline.

This SERDP sponsored technology has demonstrated a five-fold reduction, i.e., from 24 percent to 5 percent, in the rejection rate during the loading of BLU-97 submunitions (used in both the Joint Stand-Off weapon and the Tomahawk Missile). In a related development, CAME also demonstrated a new manufacturing process for the experimental DoD explosive TNAZ (trinitro azetidine) at the 20kg scale. This process increases the yield from the manufacturing process by a factor of five, from 15 percent to 75 percent. TNAZ is a fourth generation explosive that is designed to replace TNT and other explosives. This more environmentally benign manufacturing process will result in a large reduction of hazardous waste during manufacturing.

In 1996, this technology was selected along with seven other projects by the Navy to reduce life-cycle costs of five future Navy programs (new aircraft carrier, new surface combatant, new attack submarine, new aircraft, new missile system). This Green Energetics Program will provide technology for affordable, environmentally friendly energetics having increased range, payload, and kill capability for future 5-inch guns. Energetic materials are used in the 5-inch gun propelling charge, rocket motor, and (submunition) warhead. This technology would reduce the life cycle wastes by 75 percent, increase performance by 25 percent, and reduce life-cycle costs by 25 percent. These goals will be accomplished by using new energetics materials; continuous processing techniques with automated process control; new demilitarization methods; and new design technologies.

Capacitive Deionization Technology

DoD produces large quantities of liquid waste streams as part of various manufacturing and maintenance operations and is also required to treat significant amounts of contaminated water during the cleanup of contaminated sites. Traditional wastewater treatment processes such as ion exchange produce large quantities of chemical secondary wastes. The regeneration of a single pound of ion exchange resin requires more than 100 pounds of chemical regenerant. Additionally, these traditional processes require high energy consumption due to the high temperature and pressure requirements.

Under SERDP sponsorship, researchers at the Lawrence Livermore National Laboratory have developed an innovative and highly cost-effective wastewater treatment technology, based on carbon aerogel capacitive deionization. This process makes use of scientific breakthroughs from highly classified research during the Cold War by coupling the very high surface to volume ratio and extremely low electrical resistivity properties of carbon aerogel to separate ions from solution. As a result, the economical treatment of liquid hazardous waste is feasible. The process can treat liquid hazardous waste streams while producing minimal chemical secondary waste and has a potential dual use application for desalination of

brackish water. The patented Aerogel Process Technology received a prestigious 1995 R&D 100 Award from R&D Magazine. The R&D 100 Awards, considered the Oscars of scientific invention, are an annual award to the 100 best high-technology, commercialized or commercializable technological breakthroughs. The technology recently has been licensed to build and market capacitive deionization products commercially. Small-scale commercial applications will be available in the next few years while large-scale systems may be developed in the 10-20 year time frame.

Global Environmental Change Accomplishments

Atmospheric Remote Sensing Assessment Program (ARSAP)

SERDP funded projects in the Global Environmental Change thrust area have provided fundamental insights into, and unique data on, global scale environmental processes and climate change with important scientific and defense benefits.

The SERDP funded ARSAP has been primarily concerned with global atmospheric measurements of the earth's ozone layer and the effects of clouds on solar and thermal radiation. This has been a joint DoD/DOE effort to investigate, understand, and assess global atmospheric change. This project has provided unique measurement platforms and data with which to calibrate, validate, and ultimately improve the current generation of General Circulation Models (GCMs) used to predict global warming.

In the fall of 1995, a DOE-led, multi-laboratory, multi-agency team completed a comparison of clear and cloudy sky measurements using a combination of satellite, vertically 'stacked' aircraft, and ground observations to make highly accurate solar flux measurements at different altitudes throughout the atmospheric column. Early results indicate that cloudy skies do indeed absorb as much as 50 percent more shortwave radiation than previously predicted. Uncertainties in the 'radiation-cloud interaction' account for most of the factor of 3 range in warming predicted by different models. In the fall of 1996, the science team conducted the first ever, airborne radiative flux measurements over a complete diurnal cycle. The data will further improve our understanding of radiation-cloud interactions. The science team demonstrated a new unmanned air vehicle (UAV) long endurance mission capability and provided unprecedented accuracy in atmospheric measurement of the radiative properties of clouds. In FY 1997, the DOE's Atmospheric Radiation Measurement program will continue support of this new frontier in global stewardship.

Also under SERDP funding, the Naval Research Laboratory (NRL) led an international science team that verified the Antarctic ozone hole location and upper atmosphere ozone decay through three annual cycles and developed satellite sensors for continued monitoring.

This project has also provided ground-based middle atmospheric water vapor measurements, yielding the highest quality middle atmospheric water vapor data ever obtained which is fundamental to the Network for Detection of Stratospheric Change (NDSC) program. This effort leverages on environmental sensor and platform technology developed by national security programs to study the atmosphere. In FY 1997, the continued science operations of these systems will transition to NRL and the Office of Naval Research.

Acoustic Monitoring of Global Ocean Climate

The earth's oceans also play a major role in global climate change. Scientists wish to couple basin-scale observations of ocean temperature with atmospheric observations to validate and constrain current climate prediction models which will assist to predict the extent and degree of "greenhouse" warning.

This SERDP funded project has proven that ocean basin temperatures can be determined with the required millidegree precision. Led by Dr. Walter Munk of the Scripps Institution of Oceanography, a world renowned research team validated the concept that the heat content of oceans can be measured, using acoustic transmissions, with the precision and accuracy necessary to detect global climate change (1 second time difference in acoustic transmission travel time over 5,000km=0.1°C change in heat content). This breakthrough research will: enhance global ocean model validation; provide new understanding of ocean structure; and determine the impact of global ocean variability.

Advances in low frequency source manufacturing technologies has provided the cost reduction, reliability and system performance needed for long-term ocean data collection programs. With this data, development and application of coupled ocean/atmospheric modeling and prediction systems will lead to practical applications, such as better prediction of "El Nino" effects throughout the Pacific with recommendations on minimizing the economic impact. Results will improve the Navy's understanding of basin scale variability and the resultant effects on passive acoustic coherent signal processing in littoral areas.

Additionally, the international community benefits from the comprehensive marine mammal monitoring research which provides benchmark scientific data never before available on the impacts of low frequency sound on marine mammal behavior, to aid in setting better, environmentally safe criteria for noise in the sea. The project specially developed an acoustic transmitter, based on Navy low-frequency active sonars, set on the bottom off the California coast, especially instrumental Navy SOSUS receivers throughout the northeastern Pacific ocean. The transmissions, some over 100,000 kilometers, have also demonstrated remarkable stability, suggesting that sophisticated coherent signal processing techniques may work in anti-submarine warfare applications over these distances. Initial results of the marine mammal research indicate no adverse affects on marine mammals and further supports the SERDP Conservation Project Marine Mammal Response to Low Frequency Sound (CS-1069).

III. PROGRAM DESCRIPTION

FY 1996 and FY 1997 Programs

The FY 1996 and FY 1997 SERDP Programs were prepared in accordance with the direction provided by Congress and guidance issued by the SERDP Council. Each SERDP project was selected after a thorough review by several levels of technical competency, including a downselect by the submitting organization, a review by the Technology Thrust Area Working Group, and for the new starts and continuing projects valued in excess of $900 thousand, a detailed technical evaluation by the Scientific Advisory Board.

The FY 1996 accomplishments, FY 1997 plans, and FY 1998 initiatives for the research areas within the four thrusts are described in the following pages and provide direction for SERDP activities to be conducted by DoD, DOE, EPA, and other associated organizations involved in the Program. **Figure III-1** describes funding distribution to the specific Thrust Areas for FY 1996 and FY 1997.

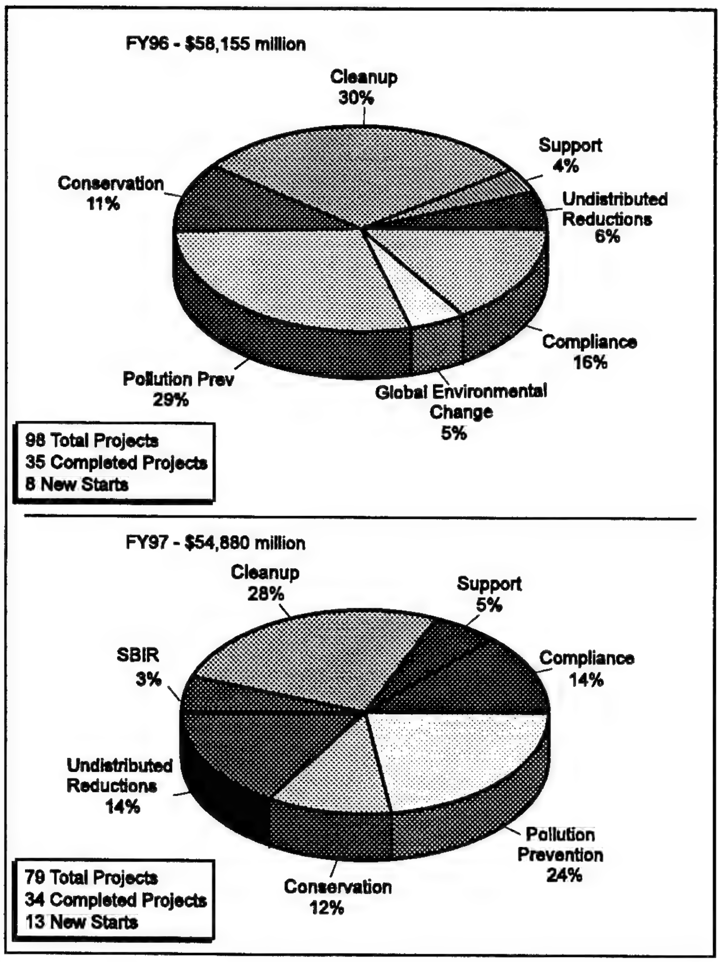

Figure III-1. SERDP Funding, FY 1996 - FY 1997

Cleanup

Introduction

DoD and DOE must protect human health and the environment, reduce remediation costs, and provide timely cleanup. Cleanup goals for the DoD are to:

- Attend to imminent threats to public health and safety;
- Remediate all defense sites having a significant public health risk as quickly as feasible within the constraints of available resources; and
- Expedite transfer of Base Realignment and Closure (BRAC) sites and Formerly Used Defense Sites (FUDS) to future owners.

DoD and DOE have a legal and moral obligation to meet the Federal, state, and local environmental protection and public health laws. They own and operate thousands of installations, ranging from training bases to industrial production plants. Many of these installations have been operating for half a century or longer. During most of this time the agencies, like much of American industry, operated their facilities without full respect for the environment.

Using today's technology, the cost to remediate DoD sites alone is estimated at $35 billion, and total cost of cleanup at current and former defense sites (including DOE sites) is projected to exceed $200 billion. DoD and DOE need technologies to reduce remediation costs, provide timely cleanup, and protect human health and the environment. Experience with past remediation technology development has demonstrated a significant return on investment. The government needs to take advantage of these high returns on R&D investment and implement new innovative technologies.

Defense environmental managers require cost-effective and timely remediation capabilities that focus on assessment, characterization, and treatment. Each Service has submitted its User Requirements for Cleanup, which are prioritized in the DoD Environmental Technology Requirements Strategy. These requirements can be grouped into environmental concerns. Within the Cleanup Technology Thrust Area, the primary environmental concerns are the need to:

- Implement timely, effective, and affordable methods for site characterization;
- Ensure the use of effective, affordable remediation technology; and
- Comply with various Federal, State, and local regulations for site remediation.

These concerns are addressed by the Cleanup subthrusts and research areas as depicted in the **Figure III-2**.

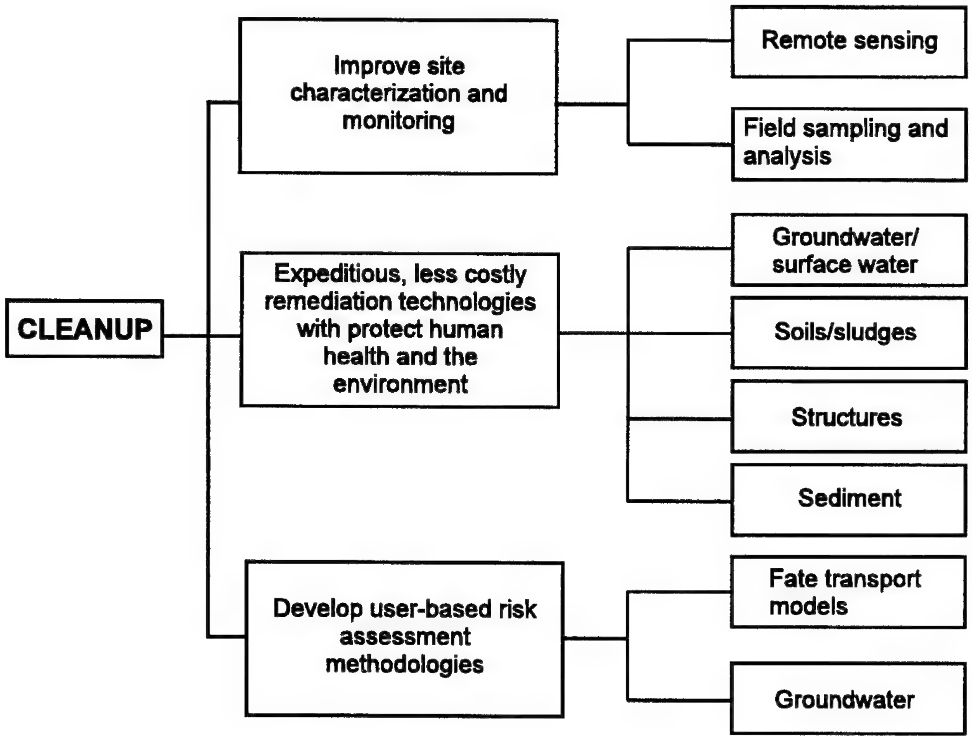

Figure III-2. Cleanup Taxonomy

Figure III-3 shows the FY 1996 and FY 1997 funding by subthrust area. For FY 1996, the Cleanup Technology Thrust Area received approximately 30 percent of the SERDP budget, which is more than any other technology thrust area. In FY 1997 and beyond, this situation will change as emphasis transitions from addressing immediate cleanup problems to preventing future ones with the Pollution Prevention Technology Thrust Area receiving a greater relative amount of funding.

Principal Driving Requirements

The first subthrust area in Cleanup seeks to develop improved and less costly investigation and characterization technology for locating and characterizing wastes. Within this subthrust, the location, identification, and remediation of unexploded ordnance (UXO) has been identified by the services as the highest priority user need. It poses an enormous challenge to the effective cleanup of many DoD sites, primarily on land but also under water. Current estimates indicate that up to 11 million acres of land in the U.S. are suspected to contain

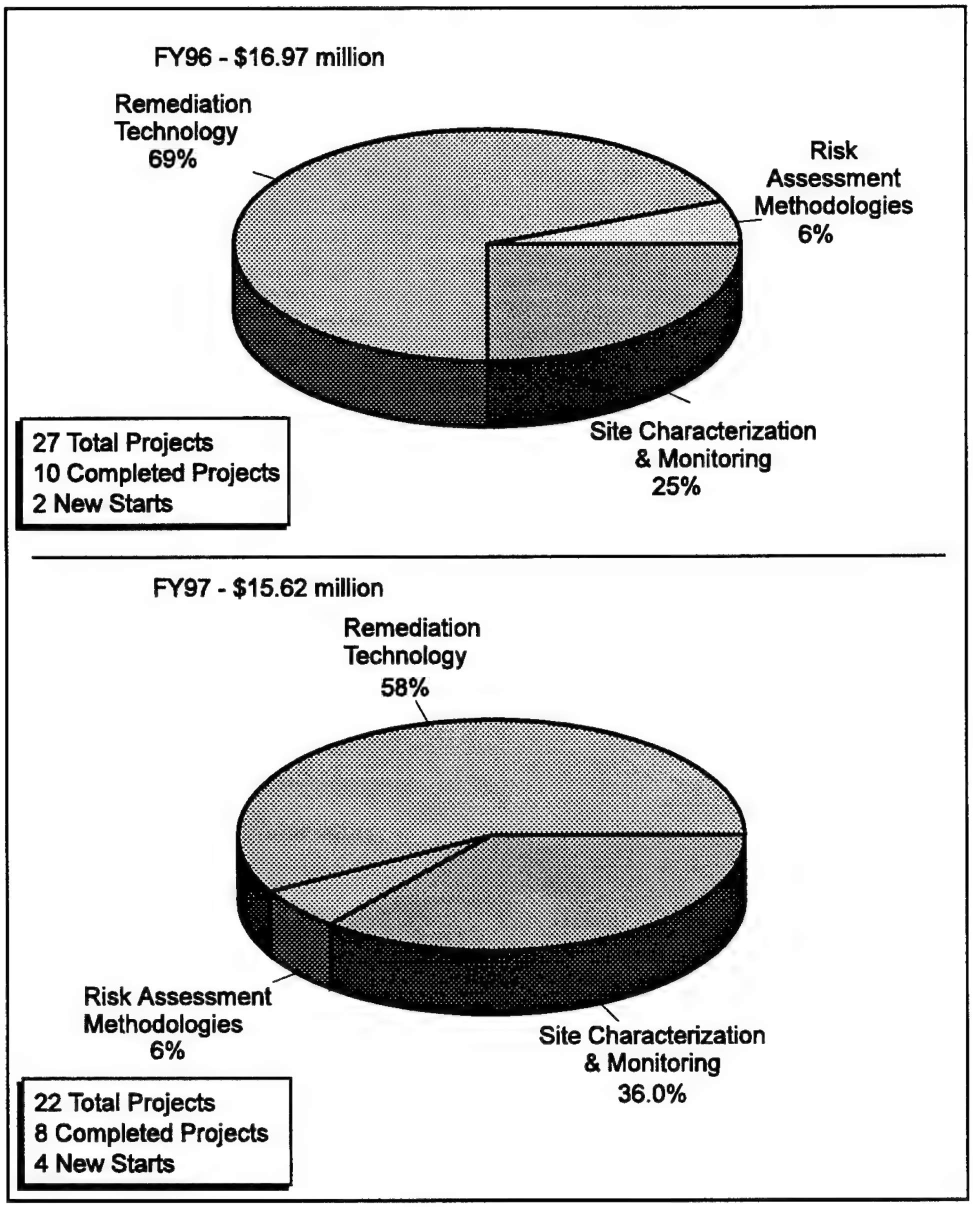

Figure III-3. SERDP Cleanup Funding, FY 1996 - FY 1997

UXO as a result of military training and weapons testing activities--6,000,000 acres of UXO contaminated Army and Navy land, approximately 5,000,000 acres on Department of Interior land, and at least 50 sites at sea. These lands represent a full range of terrains, vegetation content, soil types, and geophysical characteristics. The present cost, driven largely by the need to exercise extreme safety precautions, ranges from $1,500 per acre for surface UXO to at least $5,000 per acre for sub-surface ordnance.

In addition to UXO, chlorinated solvents represent a class of contaminants that is detected at more DoD sites (and CERCLA and RCRA sites for that matter) than any other contaminant group. Chlorinated solvents have been used in massive quantities over the last four decades. Release of these liquids to the environment accounts for a significant portion of environmental contamination requiring cleanup, as these contaminants have migrated through the subsurface and entered groundwater at over 1,000 DoD sites. There is a comparable degree of contamination at DOE and private Superfund sites.

Cleanup's second subthrust is to develop expeditious, less costly remediation technologies. Because subsurface contamination has been the biggest factor, limiting site remediation at most DoD facilities, this subthrust is directed primarily at developing technologies to better address groundwater. Current groundwater treatment strategies typically employ pump-and-treat technologies which are expensive to operate and very slow to achieve lasting cleanup because they are often ineffective in removing the source of the groundwater contamination. The major limitations to the use of conventional pump-and-treat technology relate to difficulties in extracting contaminants from source areas where non-aqueous-phase liquids (NAPLs) exist. Furthermore, presently employed technologies applied in pump-and-treat such as air stripping or activated carbon treatment do not result in final destruction of contaminants. The currently available technology for treatment of contaminated soil sources, excavation followed by incineration, is also very expensive to operate.

Soils and sediments contaminated with Polychlorinated Biphenyls (PCBs) represent one of the most challenging compound groups under investigation in this subthrust. PCBs are found at many DoD installations due to improper disposal of hydraulic fluids and waste lubricating oils. Soils contaminated with Poly Aromatic Hydrocarbons (PAHs), which are one of the most regulated groups of compounds due to their carcinogenic properties, are also one of the major remediation challenges in this subthrust because of their large and complex molecular structure which makes them difficult to degrade biologically.

The challenges facing those involved with the nearly 17,000 sites on DoD installations potentially requiring environmental clean-up include: (1) distinguishing those sites that pose significant environmental risks from those that pose little risk; (2) prioritizing contaminated sites by the degree of risk posed; (3) quantifying the risks at each site; and (4) developing appropriate remedial actions and clean-up goals. Development of improved techniques for risk assessment, which provides a logical framework for making such decisions, is a DoD priority and the focus of this third Cleanup subthrust. The effectiveness of existing methods will be expanded by research directed at problems particularly evident at DoD installations.

Leveraging with other defense Science and Technology programs and industry, the Cleanup Technology Thrust Area focuses on the following research and development (R&D) objectives:

- Develop reliable and cost effective means to identify, assess, and clean lands and underwater areas (inland, estuarian and marine) contaminated with unexploded ordnance;

- Develop investigation methods and technologies that are capable of locating and characterizing wastes in a timely, cost effective, and quality manner;

- Develop innovative, compliant technologies that reduce remediation costs for sites containing explosives, propellants, fuels, solvents, heavy metals, organic contaminants, radioactive (low-level or mixed wastes), and other inorganic contaminants;

- Facilitate transfer of cleanup technologies to field use. This includes, but is not limited to encouraging the use of the National Environmental Technology Test Sites;

- Develop cost-effective, methods and tools to determine fate, transport, and effects of significant defense-related contaminants; and

- Develop risk-based modeling and simulation methods for hazard assessment and establishing cleanup priorities and scientifically defensible levels.

Cleanup Program

The following list reflects FY 1996 completed projects and projects continuing into FY 1997. Also included are titles of projects commencing in FY 1997. Complete descriptions of all of the projects for FY 1996 and FY 1997 may be found at the listed page numbers in Appendix A - Cleanup Project Summaries.

Subthrust 1 - *Improve Site Characterization and Monitoring*

Subthrust 2 - *Develop Expeditious, Less Costly Remediation Technology*

Subthrust 3 - *Develop Risk Assessment Methodologies*

FY 1997 New Start Projects
None

FY 1998 Cleanup Statements of Need

UXO detection continues to be the number one priority in the Cleanup Thrust area. To this end, a FY 1998 Statement-of-Need has been issued, **Novel Systems for the Detection and Identification of Buried Unexploded Ordnance (UXO)**, focuses on the need to develop, refine, and integrate novel sensing technologies with high performance sensor fusion and signal processing algorithms. The primary thrust of this need is oriented toward UXO clearance in noncombat situations. The result will be enhanced detection, location, and discrimination of buried UXOs under a wide range of environmental conditions.

The second new initiative within this thrust area is **Dense Nonaqueous Phase Liquid (DNAPL) Source Zone Identification**. In the DNAPL Source Zone Identification area, a FY 1998 Statement-of-Need has been issued which seeks innovative technologies to detect, locate, quantify, and determine the horizontal and vertical extent of DNAPLs (ganglia and free product phases) in the subsurface environment. Emphasis is on nonintrusive or minimally intrusive technologies for identification of DNAPL source zones. It focuses on innovative solutions and approaches that would ideally provide the desired information in real-time and in an easily interpretable format rather than enhancements or modifications of existing technologies. Efforts will complement or interact with other research in this area of sensor development.

The third FY 1998 proposed new initiative is **In-Situ Treatment/Stabilization Technologies: Cleanup of Contaminated Groundwater, Soils, and Sediments**. This wide-scope area of need addresses issues of remediation of soils, sediments, and groundwater containing multiple, possibly interacting contaminants, and the investigation of the feasibility of cost-effective treatment trains for these materials. The primary requirement is to capture the private sector capability to develop innovative, in-situ treatment/containment/stabilization technologies combined with volume minimization, which will potentially have a high payoff.

The last FY 1998 proposed new initiative is entitled, **Risk Based Cleanup Assessment Techniques**. This initiative has been issued to develop scientifically defensible response analysis techniques as drivers for risk assessment methodologies used to screen hazardous waste sites. Extrapolating these techniques to ecologically relevant parameters and quantifying uncertainty will facilitate technically defensible and cost effective environmental risk assessments (i.e., "how clean is clean").

Detailed descriptions of the Cleanup Statements of Need may be found in Appendix F.

Compliance

Introduction

The Departments' Compliance goals are twofold:

- To ensure that all applicable environmental rules and regulations are met; and
- To eliminate or reduce the chances for Notices of Violation (NOVs).

Within the United States, DoD must comply with federal laws such as the Clean Water Act (CWA), the Clean Air Act (CAA), and the Resource Conservation and Recovery Act (RCRA), as well as state and local regulations. These laws result in requirements for the treatment and disposal of wastes generated by DoD operations and vessels, and to the open burning and open detonation (OB/OD) of waste energetics. Requirements based on the 1990 CAA amendments related to atmospheric emissions of hazardous air pollutants (HAPs), volatile organic compounds (VOCs), and nitrogen oxides (NOx) are also emerging.

At the international level, the International Maritime Organization's Marine Pollution Convention (MARPOL) Annexes (to which the United States subscribes) are restricting or prohibiting DoD operations in international waters and MARPOL Special Areas unless vessels meet international environmental statutes. In addition, countries that host DoD facilities are implementing and enforcing compliance with regulations and standards that restrict or prohibit DoD operations in foreign ports and bases.

Virtually all DoD activities and assets are subject to compliance with a wide range of environmental statutes and regulations that have impacts ranging from control of hazardous materials and effluents to treatment methodologies. Affected DoD activities and assets include: training and operational installations; ordnance and weapons manufacturing; repair and rebuilding installations; and ships and aircraft operations. DoD is projected to spend between $2–3 billion annually for environmental compliance through the year 2000. New technologies must be developed to reduce this cost and enable the DoD to fully comply with increasingly stringent requirements so that it may fulfill its mission unencumbered by regulatory fines, restricted access, and negative public reactions.

The mission of the Compliance Technology Thrust Area is to conduct research and development to support waste treatment and disposal, environmental monitoring, noise assessment and mitigation related to human impacts (a subthrust area scheduled to be moved to the Conservation Technology Thrust Area in FY 1997), marine risk assessment, and environmental management that is not directly related to site restoration but related to meeting current and future environmental compliance requirements of DoD and DOE. It also includes end-of-pipe recycling (i.e., waste that is recycled for other than its original

purpose). Further, it addresses understanding the fate and transport of defense-related air and wastewater discharges. It does not include elimination of waste streams through substitution or process modification. These are included in Pollution Prevention.

Principal Driving Requirements

The primary concerns in this technology thrust area include: loss of operational capability, the cost of regulatory compliance, and significant legal requirements. Each uniformed Service has submitted its User Requirements for Compliance, which are prioritized in the DoD Environmental Technology Requirements Strategy. These primary DoD environmental concerns reflect the need to:

- Better characterize DoD wastes and pollutant behavior;
- Control and monitor air and wastewater discharges;
- Develop improved fate and transport prediction capabilities for discharges;
- Minimize and control shipboard and land-based sources of solid waste (including plastics);
- Develop effective treatments of hazardous waste; and
- Monitor and control noise generation and propagation.

Compliance issues are addressed by the following four major subthrust areas related to affected environmental media: Air, Water, Solid, and Noise. These media are further categorized into specific types of pollutants as illustrated in **Figure III-4**.

Military operations, training, and manufacturing activities can be severely restricted if they do not comply with existing environmental regulations. In the course of implementing the Clean Air Act Amendments (CAAA) of 1990, a number of local air quality jurisdictions (many facing non-attainment status for one or more priority pollutants) have imposed local standards that are more stringent than the national emission standards. Military-unique systems (e.g. liquid-fuel rockets, military jet engines, and mobility equipment) will require that DoD control emissions of oxides of nitrogen (NOx) and hazardous air pollutants (HAPs), including volatile organic compounds (VOCs), at DoD installations. These emissions frequently are episodic (e.g., jet engine test cells; painting, stripping and cleaning operations).

Existing Clean Air Act regulations and anticipated future restrictions on NOx/HAPs/VOCs are testing the limits of existing emissions control technology which suffer from significant

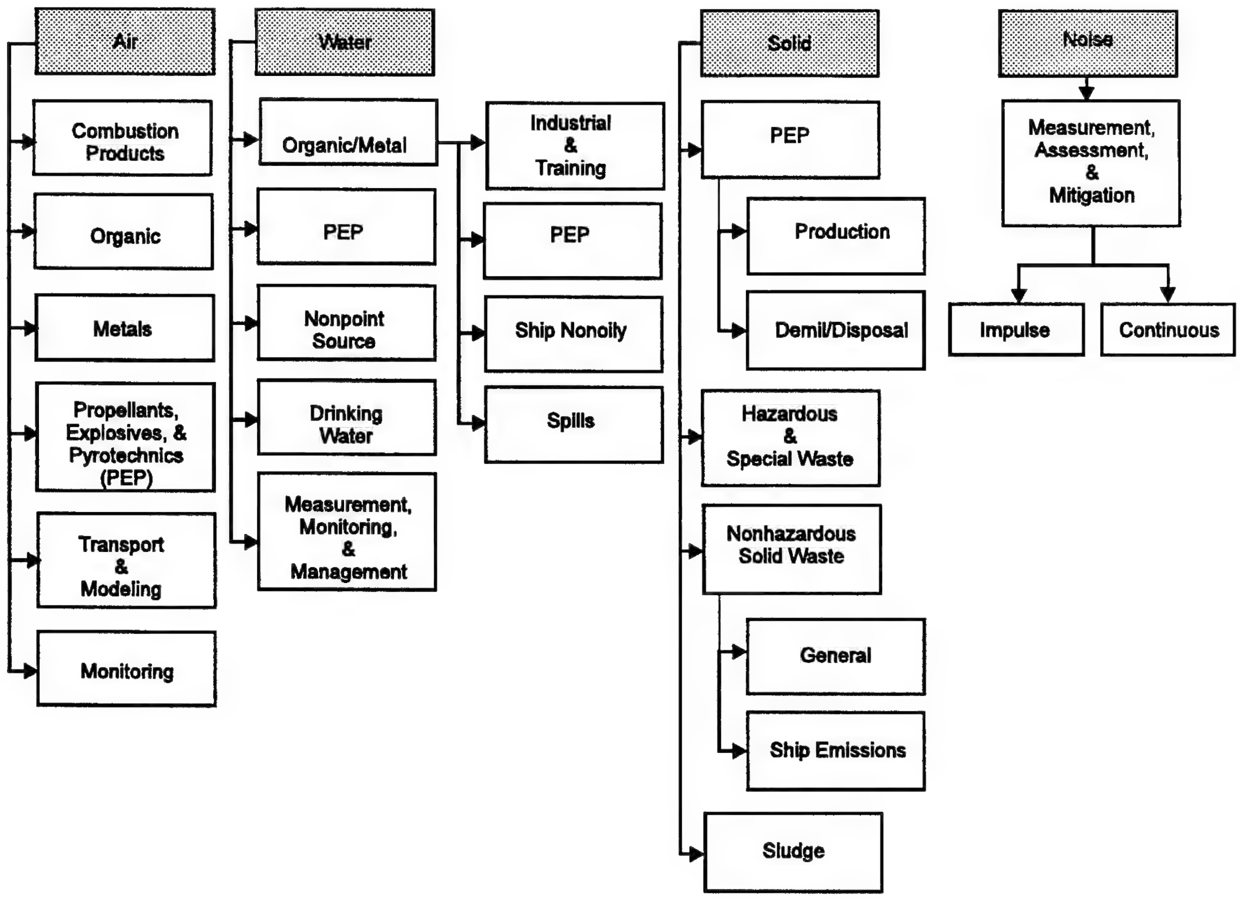

Figure III-4. Compliance Taxonomy

drawbacks (e.g., a reduction in realized power). Without new technology, the curtailment of missions, closing of facilities, and assessment of fines are real possibilities.

The environmentally-safe disposal of UXO found during BRAC and FUD site remediation and the huge stockpile of munitions and propellants accumulated by all parties during the Cold War present a substantial challenge worldwide. More than 60 percent of these materials are not amenable to disposal by disassembly, recycling or incineration. Therefore, disposal by burning and detonation is the only means applicable, a relatively simple and cost effective method for stockpile reduction but one that can generate air pollutants. Concerns about the short and long term impacts of OB/OD activities on the health of humans and ecosystems have severely restricted and sometimes prohibited OB/OD in the U.S. and many other countries.

Lead-based paint has been used on more than 1 billion square feet of DoD structures and buildings including more than 200,000 DoD family housing units in the continental United

States and 22,000 in Hawaii. Lead-based paint is a potential hazard to occupants, especially children below the age of 6 years. The cost of removal of lead-based paint from DoD structures and buildings is estimated to be more than $1 billion and presents a health hazard to remediation workers using current technology.

The Clean Water Act of 1977 prohibits the discharge of untreated sewage (blackwater) by ships in navigable waters. Shipboard graywater is the product of hotel and commissary-type activities aboard U.S. Navy ships. Common sources of graywater are showers, sinks, and galley and scullery equipment. No graywater holding capacity has been required for U.S. Navy ships with the exception of operations within the Great Lakes. However, with anticipated tightening of global wastewater discharge regulations, the Navy has identified the need to develop technologies that are appropriate for the control and treatment of combined shipboard graywater and blackwater (i.e., non-oily wastewater) as one of their environmental priorities. Further, DoD must meet international environmental regulations for the disposal of solid waste and plastics at sea. To address this need, the Navy must develop compact, efficient equipment for the destruction of solid waste onboard DoD vessels.

Preservation of training, testing and readiness requires that DoD be capable of controlling, assessing, managing and monitoring noise impacts in the vicinity of its bases and installations. It is becoming increasingly difficult to consistently meet this objective. The direct impact is a loss of training and readiness capability through the closure of ranges and firing points, altered flying routes, less realistic training procedures, and nighttime curfews. DoD has lost significant mission capability at over 50 installations as a result of noise impacts.

Figure III-5 shows the funding by subthrust area. For FY 1996, Compliance received approximately 16.5 percent of the total SERDP budget. In FY 1997 and beyond, a slight decrease in SERDP's Compliance Technology Thrust Area investment is anticipated, although this could change with a shift in new environmental regulations. Further, SERDP will shift all noise related research to the Conservation Technology Thrust Area as most noise impacts are either related to their effects on threatened and endangered species or their effects on cultural artifacts.

Leveraging with other Defense science and technology programs and industry, the Compliance Technology Thrust Area focuses on the following research and development objectives:

- Develop control, treatment and disposal technologies for ship operations (bilge, grey/black wastewater, solid waste, and air emissions);
- Develop environmentally and economically acceptable disposal alternatives to open burning or open detonation of propellants, munitions and energetic materials;

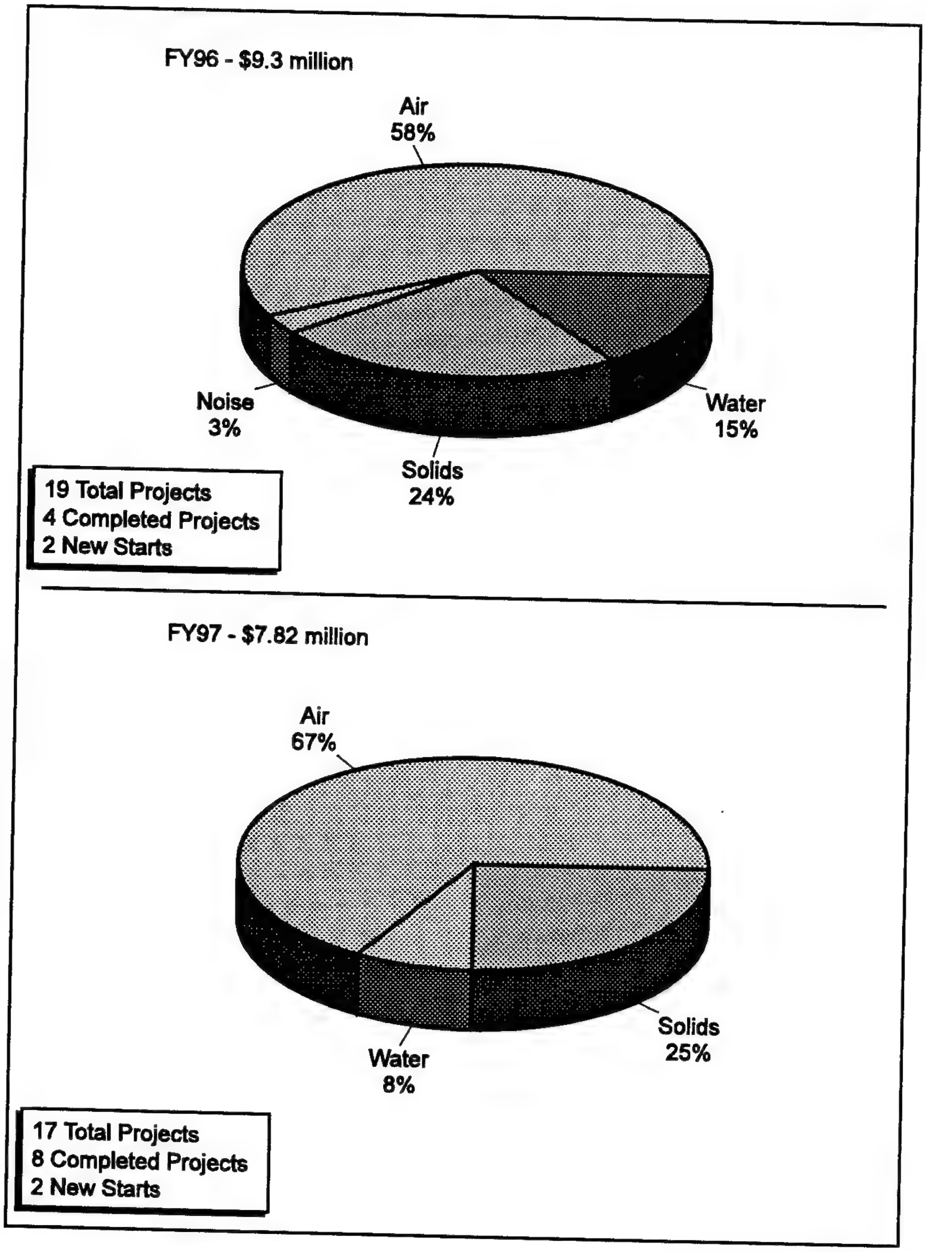

Figure III-5. SERDP Compliance Funding, FY 1996 - FY 1997

- Develop new control, treatment and disposal technologies for hazardous wastes resulting from manufacturing, maintenance and industrial operations, and installation support operations (waste water, solid waste and air emissions);

- Develop control and monitoring techniques for non-energy related air toxic emissions to include development and testing of models to predict emissions of, and exposures to, pollutants from Defense facilities and to design effective, multimedia environmental management strategies;

- Develop management and mitigation technologies for noise pollution;

- Develop improved monitoring, characterization and assessment tools related to environmental compliance and management;

- Develop standardized risk assessment methods, protocols, models and data for air and waste water discharges and noise related to defense activities.

Compliance Program

The following list reflects FY 1996 completed projects and projects continuing into FY 1997. Also included are titles of projects commencing in FY 1997. Complete descriptions of all of the projects for FY 1996 and FY 1997 may be found at the listed page numbers in Appendix B - Compliance Project Summaries.

Subthrust 1 - *Air*

Page

FY 1996 Completed Projects

None

FY 1997 Continuing Projects

FY 1997 New Start Projects

Subthrust 2 - *Water*

Subthrust 3 - *Solid*

Subthrust 4 - *Noise*

FY 1998 Compliance Statements of Need

NOx Control Technology For DoD-Specific Combustion Devices seeks to develop innovative technologies for reducing nitrogen-based emissions from the following military-unique sources: (1) liquid-propellant rocket fueling or defueling operations; (2) aircraft

turbine engine exhausts; and (3) diesel- or turbine-powered mobile heavy equipment subject to limitations to increased size or weight. Operational mission capability will be preserved by: (1) meeting increasingly stringent regulatory standards; (2) decreasing the generation and disposal cost of hazardous wastes from existing wet-scrubbing controls; and (3) decreasing the spectroscopic signature of tactical flight operations. All DoD Services would benefit from technology to reduce NOx emissions from a variety of vehicles.

Particulate Emissions Characterization is expected to result in the development of innovative technology for sampling and characterizing fine particulate matter (PM) in air from jet exhaust during operations, painting/depainting facilities, aircraft ground operation, and boiler operations (gas discharges). The sampling and characterization technologies should focus on particle size ranging from less than 1 to 10 micrometers and chemical composition in order to meet the National Ambient Air Quality Standards (NAAQSs) at DoD facilities. Characterization of PM emissions will allow the design of control technologies to meet the NAAQS, and will be important for accurately assessing the risks associated with PM emissions at DoD facilities.

VOC Control Technology for Aircraft Painting and Depainting Facilities seeks to develop innovative technologies and approaches that provide cost-effective control of both particulate and VOC emissions generated by spray application of aircraft surface preparation and coating activities. Promulgation of the National Emissions Standard for Hazardous Air Pollutants (NESHAPs) for chemicals that are used in the application and removal of coatings from aerospace vehicles is requiring military organizations to decide between (a) investing in control methods to bring existing painting and depainting operations into compliance with stringent emission limits, or (b) replacing existing, proven technologies with untested painting and depainting methods.

SERDP is evaluating a two-pronged effort to address the problem of **Minimization of Oily and Non-Oily Waste**. One FY 1998 Statement-of-Need is addressing both the wastewater minimization effort within the Pollution Prevention Thrust Area and a waste treatment effort, specifically directed at reducing oil concentrations in ship discharges, within the Compliance Thrust Area.

Destruction of Energetics in Production and Demilitarization: The objective of this effort will be to develop an innovative technology or a system of technologies that can effectively and efficiently treat energetic materials and render them non-hazardous using an environmentally benign process that does not employ open burning or open detonation (OB/OD). This basic or applied research effort will feed and complement the DoD's Demilitarization Program which is demonstrating alternatives to OB/OD.

Detailed descriptions of the Compliance Statements of Need may be found in Appendix F.

Conservation

Introduction

The Defense Department's goals are to conserve, protect, enhance, and manage the natural and cultural resources under its control in a manner consistent with its military mission, while simultaneously complying with all laws and regulations and providing optimal use of these resources. The Department of Energy has similar goals. Knowledgeable, proactive management of natural resources is critical because the natural environment provides the realistic training environment in which to exercise and test the capabilities of the military forces. Various statutes, such as the Sikes Act, The Migratory Bird Treaty Act, the Fish and Wildlife Conservation Act, the National Environmental Policy Act (NEPA), the Endangered Species Act (ESA), the Marine Mammal Protection Act (MMPA), the National Historic Preservation Act (NHPA), and local laws, regulations, and requirements provide specific stewardship direction for all DoD and DOE lands. However, these requirements relate generally to planning and/or avoiding adverse impacts, tasks which necessitate proactive approaches and extensive information.

Accordingly, DoD and DOE must be effective stewards of the natural and cultural resources under their direction in a proactive manner. By better understanding the environments in which they operate, the Departments can improve their resource-use decisions to promote conservation, while continuing to fulfill their primary missions. DoD's conservation concerns as depicted in **Figure III-6** can be divided into three distinct operating areas where the Department conducts training and testing and therefore impacts the natural environment: air, land, and water (oceans and coastal waterways). Since these mediums are so vastly different, corresponding Conservation R&D plans and programs are likewise very different.

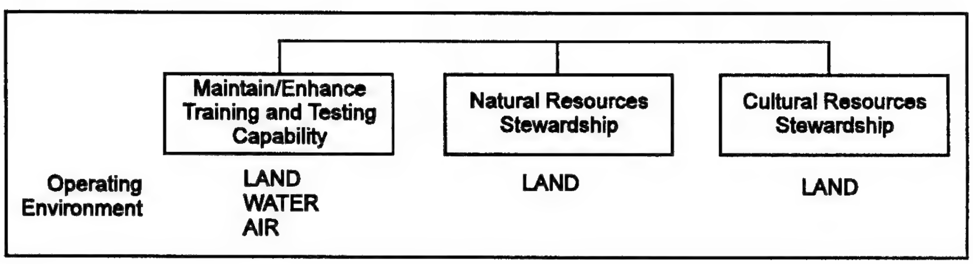

Figure III-6. Conservation Taxonomy

Figure III-7 shows the FY 1997 and FY 1997 funding by subthrust area. For FY 1997, Conservation received approximately 8.5 percent of the SERDP budget. In FY 1997 and beyond, Conservation will gradually grow to support a sustainable future in Defense.

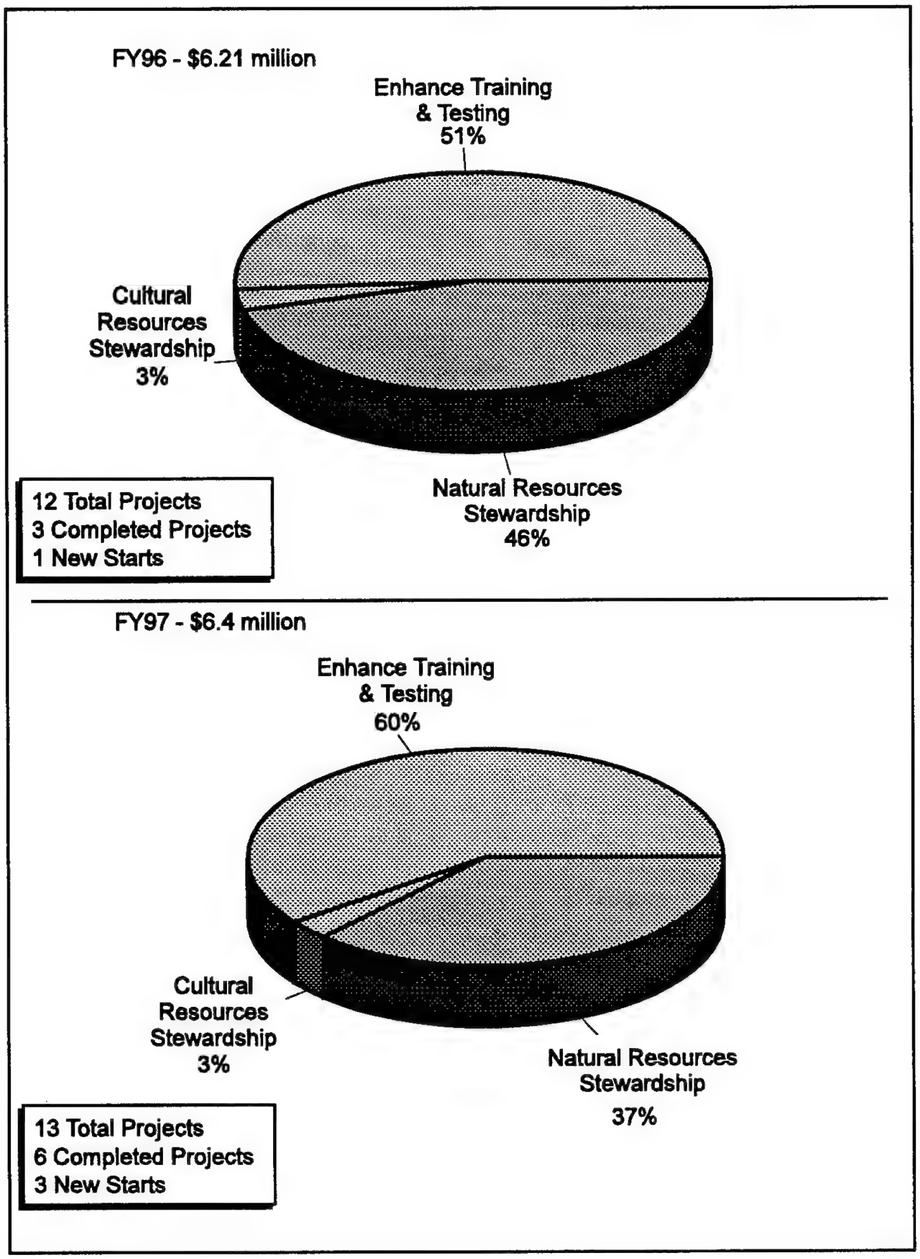

Figure III-7. SERDP Conservation Funding, FY 1996 - FY 1997

Principal Driving Requirements

Each uniformed Service has submitted its User Requirements for Conservation, which are prioritized in the DoD Environmental Technology Requirements Strategy. These individual requirements affect all operating environments and can be grouped into three related but distinct principle driving requirements, which are the needs for DoD:

- To maintain and enhance its training and testing capability to ensure military readiness;
- To steward and protect the natural resources under its control; and
- To steward and protect the cultural resources under its control.

In the Land Operating Environment, the Department of Defense (DoD) manages more than 900 installations that collectively comprise about 25 million acres. Installations range in size from more than 300 million acres to less than 10 acres. With broad geographic distribution (largely domestic but some foreign), DoD lands represent a remarkably diverse collection of ecosystem and habitat types, including forests, grasslands, wetlands, and deserts. DoD's ability to conduct realistic training exercises and to test weapon systems and equipment cannot be ensured without responsible stewardship and sensible management and conservation practices.

In the Air Operating Environment, the Air Force is required to assess the impacts of proposed aircraft operations on the environment. Many of the assessments accomplished to date contain unsubstantiated, anecdotal remarks concerning the effects of aircraft noise on wildlife. Quantitative data are needed for environmental planners at the major command and Air Staff levels to defend the Air Force's low altitude Military Training Routes (MTR), which are essential for combat training. The U.S. Fish and Wildlife Service can and has stopped proposed low altitude flight activities with formal Section 7 consultations in accordance with the Endangered Species Act.

In the Water Operating Environment, the Navy must comply with the National Environmental Policy Act (NEPA), the Endangered Species Act (ESA), and the Marine Mammal Protection Act (MMPA) in all operations and tests. This is a difficult task when "take" is defined under the MMPA to mean "harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal." The term "harass" can have a variety of meanings, in some cases including any act causing a marine mammal to change direction.

The Departments of Defense and Energy lands are subjected to a wide variety of uses ranging from military training to hazardous waste disposal to timber production. Nevertheless, these lands are often the last large natural areas in otherwise developed environments. As such, they represent valuable resources for preserving the biodiversity of their local regions, and they serve as refuges for a wide variety of threatened and endangered species. Nearly 1,000 species in the US are protected under the Endangered

Species Act (ESA), while thousands more are candidates for listing. Over 300 listed and candidate species, in addition to nearly 300 state listed species and species of concern, are known or suspected to reside on military lands. This can lead to mission constraints and impediments to land acquisition, potentially leading to reduced defense readiness; lengthy and costly litigation; and sometimes criminal and civil penalties. DoD's ability to address this issue is limited because of inadequate information on distribution and abundance of threatened and endangered species (TES) and their habitats on military land, the effects of mission activities on TES and supporting ecosystems, and appropriate mitigation and management options.

Furthermore, military facilities face increasing demands as a result of base closures and realignments, new weapon systems and equipment requiring greater training ranges, additional regulatory constraints, and changes in tactics and doctrine. Training intensity on remaining installations will continue to rise, often preventing full recovery of vegetation between training exercises. On-site and off-site environmental impacts, wildlife conservation issues, cultural resources concerns, and the need for training realism all dictate that natural resources must be maintained and enhanced on these installations. The tasks of balancing military land uses, complying with resource regulations, and assessing impacts on the sustainability of both the resource base and the military mission are complex and challenging. Activities to alleviate one problem can often exacerbate others. All too often, decision-makers on military installations are faced with making critical land management decisions without the benefit of complete environmental information nor complete knowledge of other, competing objectives and/or land use requirements.

The current reliability associated with the detection and location of cultural and archeological artifacts is minimal. Once a cultural or archeological resource site is identified, it must then be assessed in order to determine its significance. Currently, the costs associated with Phase II assessments of cultural and archeological resources are quite high. In the Army alone there are approximately 120,000 archeological sites, of which only 10 percent have been assessed and their significance determined. In addition, DoD must comply with the requirements of the Native American Grave Protection and Repatriation Act (NAGPRA), which protects Native American artifacts and cultural items, and the Archeological and Historic Preservation Act, which requires evaluation of proposed activities on the cultural environment. New techniques and capabilities are needed to reduce the costs of compliance and to avoid delays and the possibility of damaging artifacts when an unanticipated but significant discovery occurs at a construction site.

Leveraging with other Defense Science and Technology programs and industry, SERDP focuses on the following Conservation research and development objectives:

- Develop standardized, cost effective methods to inventory, characterize, and monitor natural and cultural resources to help ensure compliance with applicable laws and requirements. Where appropriate, use defense-unique data collection and assessment tools to develop these methods;

- Develop and demonstrate more effective methods and techniques to maximize availability of military lands in support of military missions, with minimal impact to natural and cultural resources in a manner consistent with the Services' mission and Federal environmental regulations;

- Develop and demonstrate efficient and effective techniques to proactively conserve and restore natural and cultural resources, particularly threatened and endangered species and the ecosystems on which they depend;

- Develop and demonstrate effective, user-friendly computer-based models to determine the incremental and cumulative impact of military activities on natural and cultural resources, and assess effectiveness of conservation and restoration techniques;

- Develop state-of-the-art techniques to assess and predict the impact of military use on those critical elements of the ecosystem impacting biodiversity;

- Develop the needed methods, tools, guidelines, and decision support systems for effectively implementing integrated resource management techniques.

Conservation Program

The following list reflects FY 1996 completed projects and projects continuing into FY 1997. Also included are titles of projects commencing in FY 1997. Complete descriptions of all of the projects for FY 1996 and FY 1997 may be found at the listed page numbers in Appendix C - Conservation Project Summaries.

Subthrust 1 - *Maintain/Enhance Training/Testing Capability*

Subthrust 2 - *Natural Resources Stewardship*

Subthrust 3 - *Cultural Resources Stewardship*

FY 1998 Conservation Statements of Need

There are four FY 1998 proposed new initiatives in Conservation's Maintain/Enhance Training and Testing subthrust area and three new initiatives planned in the Natural Resources Stewardship subthrust area. In the training and testing area, SERDP plans a new effort in the area of **Assessment and Prediction of Military Noise Effects on the Environment**. Military training and operations often cause tremendous increases in background noise levels in the environment. Military-related noise is caused by ground vehicles, aircraft, and weapons. Some noises may be so extreme that exposures could cause health problems. Technology gaps exist for understanding aspects of noise propagation, noise modeling, and noise effects on humans, animals, and structures. The objective of this

statement of need is to improve understanding of the impacts of military noise on the environment, and to provide tools and methodologies for noise impact assessment that would be usable by all military Services.

SERDP will pursue new research relating to **Military Training & Testing Activity Impacts on the Environment**. Military activities result in impacts to natural systems. Impacts occur in all DoD operating environments, the oceans and coastal waterways, in the atmosphere, and on land or underground. It is important to know and understand the effects, relationships, and dynamics of military activities in order to quantify risk and to respond properly. Opportunities may exist to identify high priority impact categories for which insufficient data, assessment methodologies, and/or understanding exists and to define a research study to address these insufficiencies in a strategic manner. The main objective of this statement of need is the development of effective standard and robust methods, as well as validated data defining, under varying conditions, military activity impacts on the environment.

Closely related is another FY 1998 new start area, **Mitigation/Rehabilitation of Damage Caused By Military Training and Testing Impacts**. Military training and testing often causes damage to land, vegetation, habitat (terrestrial and aquatic/marine), and other environmental components. Because these activities continually recur, mitigation and rehabilitation measures must regularly be employed to ensure ongoing sustainability of military training and testing resources, as well as to support DoD environmental stewardship responsibilities. The objective of this statement of need is the development of techniques to improve the DoD's ability to mitigate and/or rehabilitate damage or other adverse impacts, or the potential thereof, associated with military training and testing on land, water, or air.

Rounding out the training and testing planned initiatives is **Landscape Level Change Detection To Support Carrying Capacity Analyses For Military Ranges**. The Department of Defense has a need to better characterize and quantify the ability of its land resources to support military training and testing in a sustainable manner. Validated temporal and spatial techniques/methodologies are needed to monitor change in vegetation cover and condition for various ecoregions using a combination of remote imagery and field surveys. Such methods for temporal analysis and change detection need to be refined for different ecoregions. The necessary image calibration techniques must also be developed. Such capabilities must provide spatial analysis of relative change in vegetation parameters, based upon remotely sensed images at appropriate temporal intervals, which can be used to assess and recalibrate carrying capacity models and assess changing habitat conditions for threatened, endangered, and other species of interest. The main objective of this statement of need is to improve the capability of DoD land managers to accurately detect broad-scale changes occurring in the environment of land-based training and testing areas and their vicinities, including shallow coastal zones. This includes improving the capability to accurately and reliably extrapolate field data for broad-scale, full spatial coverage by the use of remote sensing techniques.

There are three FY 1998 proposed new initiatives in Conservation's Natural Resources Stewardship subthrust area. One of these addresses **Error and Uncertainty Analysis for Ecological Modeling and Simulation**. Land/natural resource management modeling and related modeling efforts require substantial amounts of data. Some of the data can be extrapolated from published literature, controlled field trials, and expert opinion, and a considerable amount is also obtained from ongoing monitoring programs. Selection of data for use in the models relies on a variety of assumptions about the important variables and parameters employed to substitute for knowledge, or lack thereof, in the complex environment that is being modeled. Assumptions play a pivotal role in the process of abstracting from reality to land management models, and must be challenged to assure that they remain valid throughout the modeling specification effort, validation trials, and the life of the model. This statement of need seeks methods and capabilities to quantify the sources of error associated with land management models, as well as their underlying assumptions and data sources, and to evaluate the consequences of changes to the models and to the input data on the reliability of predictions (outputs) produced by the models.

In order to answer large scale ecological questions, SERDP plans to initiate new research relating to **Fundamental Ecosystem Processes, Including Threatened and Endangered Species**. There are certain ecological processes of vital and immediate relevance to DoD use and management of land, marine, coastal, air, and other ecological space. These include the responses or reactions of environmental variables to military activity impacts, and to DoD management and mitigation efforts, processes such as natural and artificially enhanced recovery, adaptation, and natural mitigation. Among the kinds of questions to be asked are: "How does the ecosystem/species/habitat respond to military impacts over the short and long term, and what can we do to enhance the positive effects of these natural processes? Is it effective and necessary to try to enhance the natural processes, or not?" The main objective of this statement of need is to: (1) gain the basic knowledge necessary to support decision making for sustained use, management, mitigation, and restoration of ecosystems used or impacted by military training and testing; and (2) develop methods to characterize a natural setting and its dynamic ecological processes in order to accurately test new product performance in the context of the environment. Fundamental ecosystem processes knowledge is needed in particular to support regional-scale or large-scale management, enhancement, and recovery of threatened/endangered plant and animal populations within the context of their natural plant communities.

SERDP also plans a new initiative to explore **Ecosystem Fragmentation, Including Threatened and Endangered Species**. Habitat fragmentation has been identified as the most significant threat to biodiversity world-wide. The two components of fragmentation are: 1) reducing overall habitat area; and 2) division of the remaining habitat into smaller and more isolated parcels which may not be enough to sustain the organisms and the ecosystems upon which they depend. As fragmentation increases, habitat patches decrease in size and become more isolated, until eventually the gaps occupy more space than the habitat does. Fragmentation has deleterious effects on biodiversity at the landscape level, species richness level, and genetic diversity level.

Detailed descriptions of the Conservation Statements of Need may be found in Appendix F.

Pollution Prevention

Introduction

The Pollution Prevention Technology Thrust Area focuses on reducing or eliminating the generation of pollution within the DoD. The application of pollution prevention technologies will positively influence the other DoD environmental Thrust Areas by encouraging the use of innovative technologies and practices such as recycle, recovery and reuse, reducing pollutants to be managed at the source, and promoting the sustainable use of natural resources.

As defined under the Pollution Prevention Act of 1990, pollution prevention means "source reduction" and other practices that reduce or eliminate the creation of pollutants through increased efficiency in the use of raw materials including energy, water and other resources, or materials substitution. Source reduction is defined as any practice that reduces the amount of any hazardous substance, pollutant, or contaminant entering any waste stream or otherwise released into the environment (including fugitive emissions) prior to recycling, treatment or disposal. Source reduction does not include energy recovery, treatment, disposal, or end-of-pipe recycling if the waste is used for other than its original purpose. SERDP Pollution Prevention does address end-of-pipe recycling of wastes, if used for the same purpose. For example, munitions and their materials may be recycled for production of new munitions.

Waste minimization programs in the commercial sector have demonstrated that pollution prevention saves money. Clearly, pollution prevention in areas not being adequately addressed by private sector practices will be a key approach for DoD and DOE to meet their environmental obligations in a cost effective manner. Material substitutions, manufacturing process changes, inventory and stockpile controls, and adjustments to routine, daily processes will be required to meet these obligations.

The DoD and DOE have a number of unique functions, such as the development and operation of sophisticated weapons systems which demand specialized, high-performance materials. Many of these materials are the same toxic chemicals that are targeted for voluntary reduction. The challenge to DoD and DOE is to find new high-performance materials that are not toxic, and/or to determine innovative ways to control use of toxic chemicals in order to reduce releases and off-site transfers.

The Air Force, Army, and Navy have each submitted their Pollution Prevention User Requirements, which are prioritized in the DoD Environmental Technology Requirements Strategy. These requirements can be grouped into environmental concerns. The primary DoD environmental concerns in Pollution Prevention are the needs to:

- Identify alternatives for hazardous and toxic chemicals/materials;
- Reduce the use of hazardous and toxic chemicals/materials;
- Reduce the volume and toxicity of wastes and pollutants through source reduction;
- Improve the efficiencies of mechanical and chemical systems;
- Incorporate environmental ramifications as key evaluation considerations in major system design and acquisition; and
- Consider the life-cycle effects of materials and systems.

These Defense Pollution Prevention needs are addressed by the four major subthrust areas of Air, Water, Solids, and Modeling and Databases, which are further organized along process lines as depicted in **Figure III-8**.

The FY 1996 and FY 1997 distribution of SERDP funding for Pollution Prevention among the subthrust areas is shown in **Figure III-9**. For FY 1996, Pollution Prevention received approximately 27 percent of the SERDP budget. In FY 1997 and beyond, Pollution Prevention will grow relative to the three other technology areas of SERDP in order to meet defense users' demands for better, less costly, and cleaner weapons systems and processes.

Principal Driving Requirements

Executive Order 12856, "Federal Compliance with Right-to-Know Laws and Pollution Prevention Requirements," states that the Federal Government should become the leader in the field of Pollution Prevention through the management of its facilities, its acquisition practices, and supporting the development of innovative pollution prevention programs and technologies. The Executive Order challenges the heads of the Departments of Defense and Energy to set goals voluntarily to reduce their agency's total releases of toxic chemicals to the environment and off-site transfers by 50 percent from 1994 baseline figures by December 31, 1999.

Virtually all of DoD maintenance and repair activities involve the use of toxic or hazardous substances. The 1990 Clean Air Act Amendment (CAAA) and state and local regulations restrict the emission and disposal of these hazardous materials. Ozone depleting substances (ODSs) are being phased out of production under national policy and international

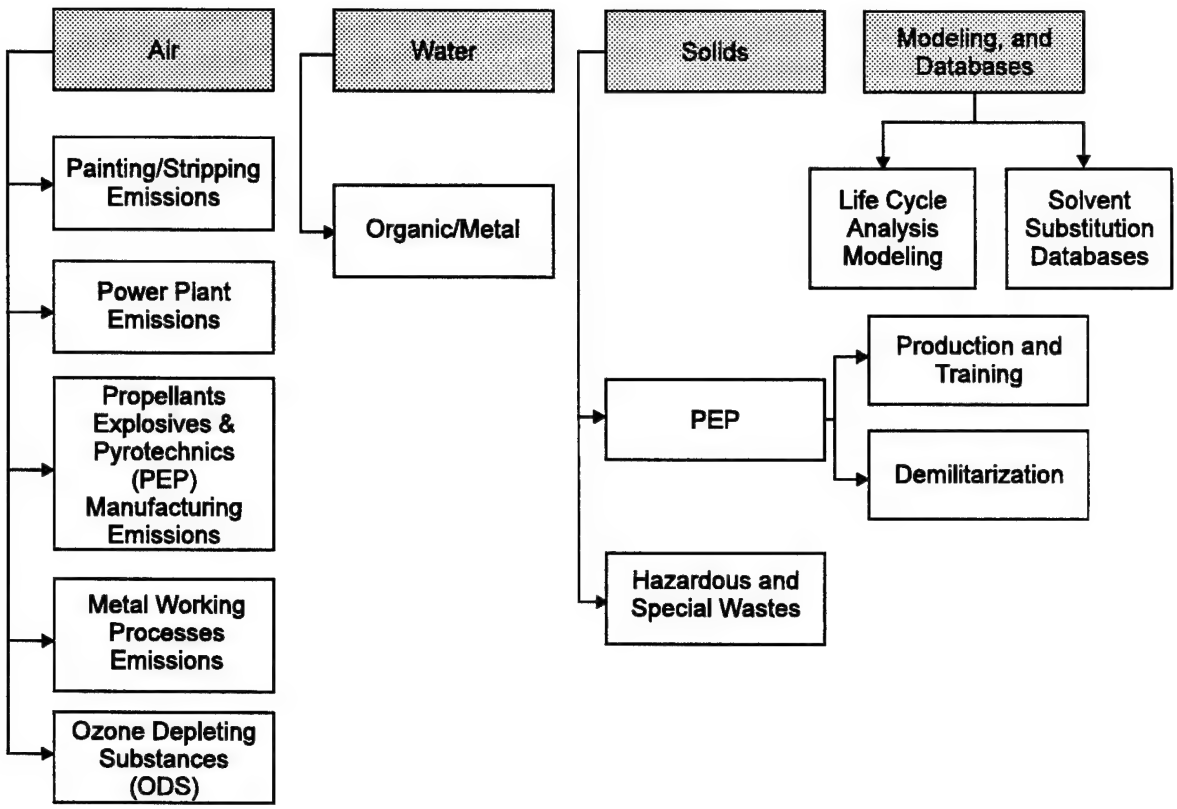

Figure III-8. Pollution Prevention Taxonomy

(Montreal) protocol. DoD directives require significant reductions in hazardous wastes and development of alternative materials and processes that meet environmental restrictions and allow DoD to continue operations. Operations and training activities at DoD installations and facilities generate large quantities of hazardous, non-hazardous, and special wastes that are expensive to manage and dispose.

During this decade, an increasing emphasis has been placed on pollution prevention to reduce environmental impacts associated with DoD weapon systems acquisition. Development and application of modeling and simulation tools to identify and test technical solutions which reduce reliance on toxic materials and processes will be required. The DoD Pollution Prevention Strategy of August 11, 1994 established a goal to identify and develop environmental life cycle cost estimating tools that inject pollution prevention and other environmental concerns into acquisition decisions.

Leveraging with other DoD, DOE, and EPA science and technology programs and industry, the Pollution Prevention subthrust areas focus on the following research and development objectives:

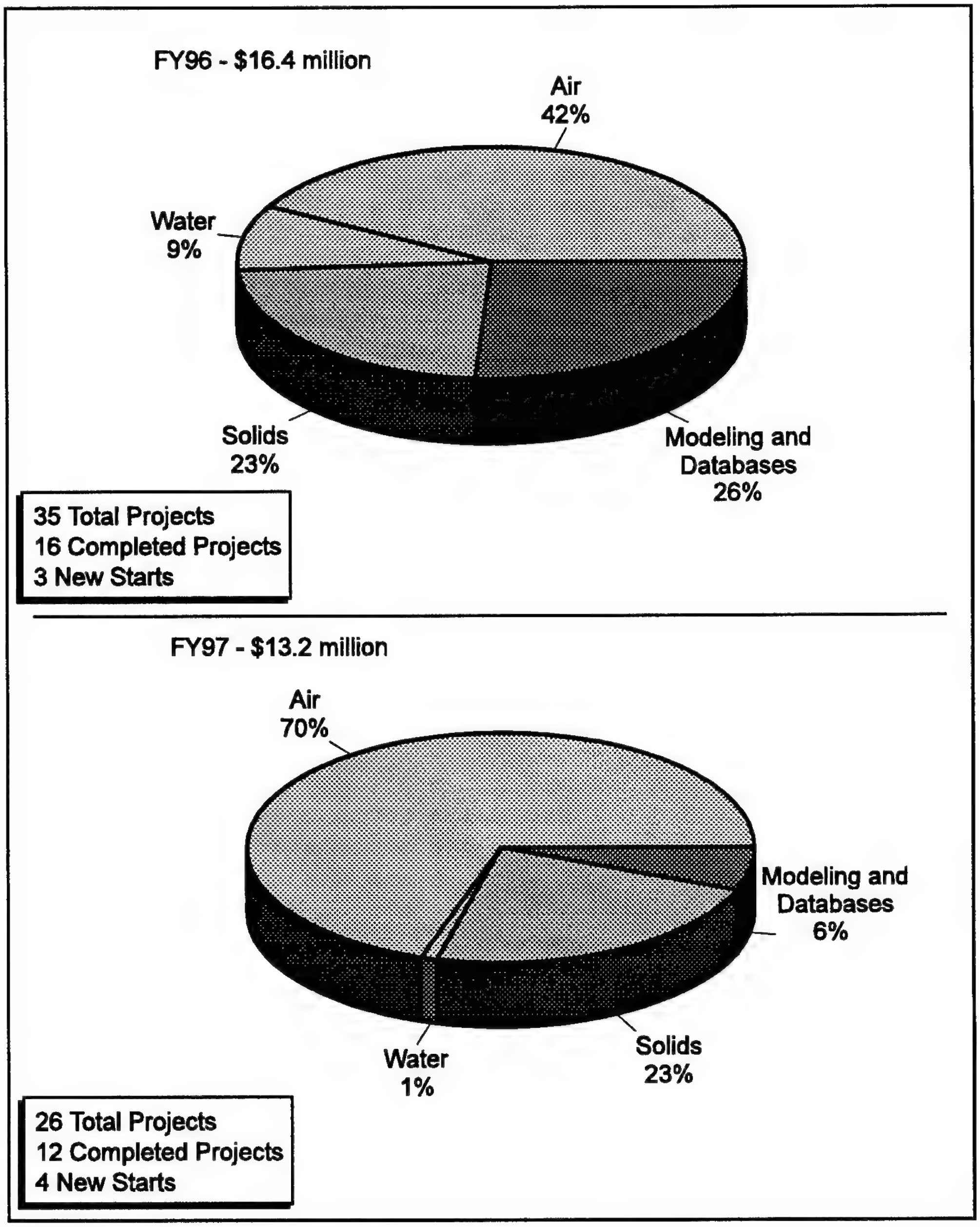

Figure III-9. SERDP Pollution Prevention Funding

- Alternative materials and processes to replace defense uses of hazardous heavy metals (e.g. chromium, cadmium, lead, nickel) and metallic compounds, and hazardous air pollutants;

- Alternatives to volatile organic compound (VOC) coatings, adhesives, sealants and lubricants that are not being adequately addressed by industry;
- Alternatives to hazardous and toxic chemicals for surface cleaning, degreasing and paint stripping;
- Alternatives to hazardous and toxic chemicals, especially ozone depleting substances (ODS) used in climate control, refrigeration, as solvents, and as fire-fighting agents;
- Techniques to regenerate, recycle, re-use, and stockpile defense unique toxic chemicals and materials;
- On-line sensors and monitoring systems to prolong usefulness of toxic chemicals in defense operations such as plating, stripping, and mechanical maintenance;
- Cost-effective, environmentally preferable packaging and recycling approaches to reduce generation of solid waste from defense-related operations; and
- Predictive models (which include environmental life cycle costing) to aid in the development of environmentally sound weapon systems and platforms during concept development, design, test and evaluation, maintenance (logistics support documentation), and decommissioning.

Pollution Prevention Program

The following list reflects FY 1996 completed projects and projects continuing into FY 1997. Also included are titles of projects commencing in FY 1997. Complete descriptions of all of the projects for FY 1996 and FY 1997 may be found at the listed page numbers in Appendix D - Pollution Prevention Project Summaries.

Subthrust 1 - *Air*

Page

FY 1996 Completed Projects

FY 1997 Continuing Projects

FY 1997 New Start Projects

Subthrust 4 - *Modeling & Databases*

FY 1996 Completed Projects

FY 1997 Continuing Projects

FY 1997 New Start Projects

None

FY 1998 Pollution Prevention Statements of Need

SERDP is proposing two new start topics in the Air Subthrust area, three in the Water area, and three in the Solids area.

Non-Toxic Aerospace Sealants and Primers will focus on the identification, optimization, field testing and demonstration of non-toxic sealants, sealers, and structural adhesives and primers in order to reduce aerospace facilities' toxic release inventory and decrease human exposure to toxic substances, primarily those that contain chromium VI. Other related materials and processes exist and also will be addressed to eliminate, to the maximum extent practical, chromates from aerospace related operations.

Alternatives to Aqueous Electrodeposition of Chrome in Gun Barrels will focus on the development of an innovative, alternative, dry (non-aqueous) process for the deposition of chrome or other materials equally suited for the bore protection of a gun barrel, replacing the

current aqueous electrodeposition process which used hexavalent chrome, a known carcinogen. Other stations of the plating process, which also produce less dangerous yet still hazardous waste such as sulfuric acid and phosphates must also be replaced.

Substitutes for Ethylene Glycol for Aircraft Deicing will focus on identification and development of innovative candidates for an environmentally benign drop-in substitute(s) for ethylene glycol-based aircraft de-icing/anti-icing chemicals, which are widely used by the Air Force and Navy. A substantial percentage of this ethylene glycol and water solution falls off the aircraft and enters the parking apron's storm water drainage system. Successful candidates must meet minimum performance requirements in the following key areas: environmental; toxicology; de-icing/anti-icing performance; and materials compatibility (MIL-A-8243D).

Alternative Materials and Processes for Tactical Vehicle Washing will focus on developing alternative technologies such as source reduction and material substitution to reduce or eliminate the use, release, and off-site transfer of toxic chemicals from tactical vehicle exterior washing processes.

Minimization of Oily and Non-Oily Waste is one part of a two-pronged approach to oily and non-oily waste generated by ships. It focuses on the development of new technologies and processes and innovative process enhancements that will reduce or eliminate the generation of oily and non-oily wastes at their source. Development of closed-loop and recycle processes which result in the minimization of waste products fall within this pollution prevention requirement. These waste minimization technologies will address the effect of the minimization process on existing collection or end-of-pipe treatment equipment. The other effort is in the Compliance Technology Thrust Area and focuses on treatment, specifically directed at reducing oil concentration in ship discharges.

Non-Polluting Composites Re-manufacturing and Repair for Military Applications: This program intends to identify and develop innovative technical solutions to solve pollution problems in composites remanufacturing and repair for military applications. Specific areas to be addressed include: resins and repair adhesives of finite shelf life; solvents and strippers; and better materials and repair methods. The cost and bulk of hazardous waste disposal will be greatly diminished for each DoD repair and remanufacturing facility. Each of these facilities could realize savings on the order of several million dollars with respect to disposal costs.

Green Packaging - Reducing HAZMAT Consumption and Hazardous and Non-Hazardous Waste Streams from Military Packaging Operations: Innovative technical solutions to urgent environmental problems attributed to DoD packaging operations and/or packaging materials need to be identified and developed. The two specific areas of packaging that are the focus of this initiative are (1) alternate materials for twenty-year storage requirement for ammunition, weapons systems, and ancillary equipment; and (2) alternate materials for five-year storage requirement for subsistence items. Solutions will focus on elimination or

reduction of the use of hazardous materials in the manufacture of packaging materials, examination of biodegradable alternatives for packaging materials, developing alternative uses for military unique packaging materials (recycling), and developing technologies to identify and sort packaging wastes to reduce solid wastes.

Manufacturing/Industrial Recycling In-Process Recycle/Recovery (Recycle and Reuse of Industrial Cleaning Rags): This work will identify and develop an innovative process(es) to remove toxic pollutants from industrial surface cleaning rags which otherwise must be disposed of as hazardous waste. The ideal technology to meet this need will have the following criteria: (1) it must render the rags free of contamination and make them available for recycling and reuse; (2) it must collect the contaminant for safe disposal, or recycle it for proper reuse, or render the contaminant non-hazardous; and (3) it must not transfer the toxic contaminants to a second media resulting in later discharge to the environment.

Detailed descriptions of the Pollution Prevention Statements of Need may be found in Appendix F.

APPENDIX A
Cleanup Project Summaries

PROJECT SUMMARY

PROJECT TITLE & ID: Encapsulated Bacteria for In-Situ PAH Bioremediation; CU-23

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: U.S. Navy

LAB: Naval Research Laboratory - Washington, D.C.

PRINCIPAL INVESTIGATOR: Dr. Barry Spargo

FY 1996 COMPLETED PROJECT

OBJECTIVE: To develop an in-situ treatment strategy using microencapsulated bacteria for bioremediation of petroleum products such as PAHs that are poorly degraded by naturally-occurring bacteria.

BENEFIT: Using microencapsulated bacteria to detoxify a hazardous waste site would be a low-cost and less disruptive alternative to excavation and off-site treatment of contaminated soils.

ACCOMPLISHMENTS: Encapsulation with polyvinyl alcohol (PVA) or calcium alginate was employed for soil and sediment applications. A system in which nutrients and oxygen sources were co-encapsulated with the bacteria was field-demonstrated in FY 1996 on PAH-contaminated soil. For jet fuels, encapsulated nutrient amendments alone were sufficient to allow degradation by indigenous bacteria.

TRANSITION: The technology will be transitioned to the industrial contractor, SBP Technologies, Inc., which collaborated with the Naval Research Laboratory (NRL) on this project and on another related SERDP project, **CU-30: In-Situ Bioremediation of Fuel and Efficacy Monitoring**.

PROJECT SUMMARY

PROJECT TITLE & ID: Rapid Detection of Explosives and Other Pollutants; CU-28

RESEARCH CATEGORY: 6.3 Advanced Development

LEAD AGENCY: U.S. Navy

LAB: Naval Research Laboratory - Washington, D.C.

PRINCIPAL INVESTIGATOR: Ms. Anne Kusterbeck

FY 1997 FUNDS: $200K

OBJECTIVE: With SERDP support, the Naval Research Laboratory (NRL) has developed a biosensor, known as the Flow Immunsensor, which can be configured to measure either discrete samples containing explosives, in under one minute, or to monitor process streams at timed intervals. Using a displacement immunoassay, multiple samples can be injected into a micro-column containing a fluorescent signal molecule bound to immobilized antibody. If explosives are present in a sample, the fluorescent molecule is displaced and detected. If the sample contains no explosive molecules, reagents are not expended. The objective of the present work is to use the existing biosensor for explosives to test soil and water samples from known sites of contamination. Operating parameters for selected molecules, including detection limits, possible interferents in samples, and useful system lifetime are being investigated. Following successful laboratory studies in the initial years of the project, on-site analyses of environmental samples, including soil and groundwater, are currently being performed to detect and quantify the explosives TNT and RDX. A portable device to improve on-site testing is also being developed.

Because the DoD has over 1,200 sites contaminated with explosives and 87 percent of these exhibit contamination in the groundwater, there is a great need to develop a fast, cost-effective biosensor technology. Remediation of munitions sites contaminated with explosives, and monitoring of the surrounding area, require accurate analyses of field samples. Tests should be conducted rapidly and on site for the most effective remediation to proceed. Recent advances in antibody technology have allowed the introduction of immunoassay techniques to environmental monitoring. Immunoassays now being marketed for environmental analysis, such as products from Ensys and Editek, while extremely selective, have several disadvantages for field use. First, the tests require multiple, timed steps, or user manipulation. Also, these techniques measure single samples rather than flow streams. Finally, costly reagents are used for each test, whether positive or negative.

TECHNICAL APPROACH AND RISKS: To adapt the Flow Immunosensor technology to site characterization and monitoring, the primary tasks in the first year of funding were to look at field samples using the laboratory device and overcome problems with interferents.

Using Cy5 fluorescent dyes and chemistry developed at NRL to minimize intrinsic fluorescence, assays for a number of relevant explosives, including TNT, RDX, PETN, and DNT have been developed for the Flow Immunosensor. Preliminary field tests designed to test the overall performance and accuracy of the sensor were conducted on groundwater samples using our current laboratory prototype at the selected test sites. For confirmation of results, an independent test for the presence of the compounds in the sample was conducted. This work was summarized in a Technical Report to SERDP, as well as an EPA report.

ACCOMPLISHMENTS: Following initial laboratory work in FY 95 to develop assays for target explosives and overcome intrinsic fluorescence, the lab prototype biosensor was successfully field-tested at two military bases identified by the U.S. EPA as priority Superfund cleanup sites [Umatilangor (Bangor, WA)], demonstrating that the Flow Immunosensor is capable of detecting TNT and RDX in environmental samples with accuracy and precision. Other work in FY 1996 focused on preliminary engineering and testing of a portable device for field use.

BENEFIT: The Flow Immunosensor has been patented and the patent is available for commercial use. The EPA has already initiated a purchase request for an instrument and will work with NRL to begin the formal methods-validation process, a two-year effort. Their plan is to use the instrument at selected Superfund sites to monitor remediation progress in parallel with the EPA-approved method. It is expected that this work will be leveraged with funds from the Environmental Security Technology Certification Program (ESTCP).

FY 1997 Milestones	Planned Date
1. Complete testing of field instrument performance	04/01/97
2. Conduct extended on-site tests to monitor groundwater remediation progress	09/01/97
3. Improve soil and groundwater detection limits to meet EPA requirements	10/01/97
4. Prepare final technical report	12/01/97

PROJECT SUMMARY

PROJECT TITLE & ID: In-Situ Bioremediation of Fuel and Efficacy Monitoring; CU-30

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: U.S. Navy

LAB: Naval Research Laboratory - Washington, D.C.

PRINCIPAL INVESTIGATOR: Dr. Barry Spargo

FY 1996 COMPLETED PROJECT

OBJECTIVE: The objective of this research project is to conduct laboratory and field demonstrations of innovative in-situ bioremediation technologies coupled with the development of a comprehensive monitoring strategy to show and evaluate the efficacy of in-situ bioremediation process/system. This objective is accomplished by the combination of application and use of stable carbon and nitrogen isotopes ratio analysis and the analysis of the contaminant concentrations of different soil matrices to achieve research-to-field demonstrations of optimized in-situ bioremediation.

BENEFIT: Stable isotope analysis allows differentiation between degradation products of natural origin and those resulting from degradation of target contaminants. Process performance could be monitored on-line. This research capability will result in a greater than 20 percent cost savings of this technology over other competitive technologies for PAH contamination.

ACCOMPLISHMENTS: By monitoring the stable carbon isotope ratio analysis of liberated CO_2, the fate of individual contaminants in a PAH-contaminated site and a BTEX spill site were successfully tracked to allow modeling, mass balance determinations, and optimization of Groundwater Circulation Well bioreactors through enhancement with nutrients and electron acceptors.

TRANSITION: The technology will be transitioned to the industrial contractor, SBP Technologies, Inc., which collaborated with NRL on this project.

PROJECT SUMMARY

PROJECT TITLE & ID: In-Situ "INSIDE-OUT" NMR Sensor for Contaminant ID; CU-38

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: U.S. Navy

LAB: Naval Command Control and Ocean Surveillance Center - San Diego, CA

PRINCIPAL INVESTIGATOR: Dr. Mark North

FY 1997 FUNDS: $300K

OBJECTIVE: The objective of this project is to determine the feasibility of adapting the emerging "INSIDE-OUT" Nuclear Magnetic Resonance (NMR) technique of compound identification to rapid site screening of hazardous waste sites. Recent developments in the area of high energy density magnets (rare earth and high temperature superconducting magnets) will allow for a significant reduction in the physical size of this type of sensor. The sensor analyses a well-defined volume of soil surrounding it, without collection of samples, for chlorinated/fluorinated hydrocarbons, fluorocarbons, phosphate based pesticides, explosives and pyrotechnic compounds.

TECHNICAL APPROACH AND RISKS: NMR Spectroscopy is a well established, non-destructive analytical analysis technique normally confined to the laboratory or testing institute, because of the requirements imposed by the generation of the essential external magnetic field. In order to create a portable field instrumentation system based on this principal, radical changes in the perceived implementation of this technique and an alternate source of magnetic fields are necessary. The concept of reversing the locations of the sample and the source of the magnetic fields required to perform NMR Spectroscopy was proposed and verified by Jackson, Burnett and Harmon for the Department of Energy, Los Alamos Scientific Laboratory in 1980. The technique developed produces a region of homogeneous magnetic field external to the apparatus allowing analysis of external samples.

The major risk area is the feasibility of applying contemporary magnet and high speed integrated electronics technology to this NMR technique. The result will be a miniaturized "Inside-Out" NMR sensor which can be utilized with current site screening methodology (test wells), and future sensor deployment platforms, for real-time site screening. With proper design and calibration, the proposed sensor apparatus will be capable of accurate in-situ identification and quantification of various subterranean chemical compounds containing hydrogen, fluorine, phosphorus, or thallium, at hazardous waste sites.

ACCOMPLISHMENTS: The initial assessment of feasibility was completed in FY 1996 with encouraging results. Unique NMR signatures have been verified for target hydrocarbon

compounds to demonstrate the feasibility of the technique for field screening, and a prototype sensor utilizing a rare earth alloy magnet has been fabricated.

BENEFIT: Rapid and cost effective screening of proven or suspected sites contaminated with chemical compounds for which it has been calibrated. The ability to identify and quantify contaminants in subterranean strata behind well casings will allow the placement of a single test well, drilled and cased to the maximum investigative depth, rather than many wells which vary in depth in order to collect the necessary strata effluents.

This single well (in place of five separate wells which differ only in depth) for each specific grid point at a hazardous waste site will reduce the number of required test wells by a factor of five. If we conservatively estimate the cost of drilling and casing a well at $20/ft, for a 50 ft well, and disposal of the tailings, at $4,000, the associated analytical laboratory analysis of the effluent, required for the test well's lifetime (x samples per year for z years as required by EPA), at $5,000, then the cost per test well is estimated to be $10,000. Further, assume that the time required to install a well and receive the initial laboratory analysis report (approximately 4 weeks) would not be lost.

Thus, if the number of well installed per year is reduced by 500, then the monetary savings will be $5 million/year. Also, the environmental and personnel health risks are reduced since the amount of hazardous tailings wastes generated during the drilling operations will be reduced in proportion to the number of wells drilled.

FY 1997 Milestones	Planned Date
1. Complete assessment of feasibility	10/30/96
2. Complete fabrication of prototype "In-Situ" sensor	01/30/97
3. Complete laboratory evaluation & calibration of prototype sensor	05/30/97
4. Plan field trials	06/30/97
5. Start field trials (Move to FY 1998 due to budget reductions)	07/30/97
6. Interim Report	10/30/97

PROJECT SUMMARY

PROJECT TITLE & ID: Mobile Underwater Debris Survey System (MUDSS); CU-52

RESEARCH CATEGORY: 6.3 Advanced Development

LEAD AGENCY: U.S. Navy

LAB: Naval Surface Warfare Center - Panama City, FL

PRINCIPAL INVESTIGATOR: Mr. Stephen Castelin

FY 1997 FUNDS: $1,120K

OBJECTIVE: The goal of the MUDSS project is to demonstrate the multi-sensor technologies (three sonars, an electro-optic, a chemical sensor, and a magnetic gradiometer) necessary for underwater surveys of shallow water, both inland and coastal sites littered with unexploded ordnance (UXO). A successful demonstration will prove the system concepts for finding and mapping the locations of UXO ranging from small shells to large bombs in water depths between four and 100 feet. These technologies can then be applied to the environmental cleanup of underwater UXO at scores of formerly used defense sites (FUDS).

MUDSS is a technology demonstration and transfer program. It marries developing mine-hunting technologies from the Coastal Systems Station (CSS) with data fusion and visualization technologies developed for NASA by the Jet Propulsion Lab (JPL). Included will be an assessment of chemical sensor technology developed by JPL for the FAA. The U.S. Army Corp of Engineers (USACE), which has the current mission for munitions remediation and cleanup for over 900 FUD sites, strongly endorsed the transition of MUDSS to an operational capability.

TECHNICAL APPROACH AND RISKS: The project has two phases. The first feasibility demonstration phase was completed in FY 95. In this phase, existing mine-hunting sonars, magnetic and electro-optic sensors were operated in a very shallow water field having targets of interest. Results showed these sensors had the potential to detect, classify and identify UXO sized targets. In addition, these data were used to benchmark existing sensor models that will be used to predict performance against other targets and environments. Sensor fusion and display concepts will be developed from the recorded data.

The second phase is the development and demonstration of a field deployable system. This phase will integrate improved sensors with real-time data fusion and displays to aid operators making target detections and classifications. A technology demonstration at a site or sites of interest is planned at the end of phase II. This phase will take 27 months and starts after phase I.

The technical risks are associated with mine-hunting sensor performance in the very shallow water against small targets. These sensors are usually operated in deeper waters (>30 feet) and against larger sea mine targets. Phase I testing showed the potential for these sensors to individually detect, classify and identify UXO in a very good environment. The environment had targets with minimal corrosion and marine growth, the bottom was sand and had very few other UXO sized objects (clutter). There is risk associated with the performance in a real FUDS environment where targets might be decomposed and the bottom may have a high amount of clutter. This is were sensor fusion will be evaluated as the method to screen out clutter from targets. Finally, integration of these very sensitive sensors into a field-deployable unit is another technical risk area.

ACCOMPLISHMENTS: In FY 1996, leveraging the Navy's sensor technology and NASA's expertise in data fusion and visualization, SERDP developed the Phase II multi-sensor MUDSS system, which is comprised of three sonars (high-and-low frequency synthetic aperture sonars, and an ahead-looking sonar for surveying UXO), an electro-optic sensor, a chemical sensor, and a magnetic field gradiometer.

BENEFIT: The exact extent and amount of ordnance at most underwater FUD sites is unknown. MUDSS will provide a capability to survey these sites to determine the extent of the problem and also a capability to locate targets for remediation. Each MUDSS sensor will out-perform any commercial off the shelf (COTS) sensor, and the integrated MUDSS system will provide performance against UXO (including buried ordnance) far exceeding any COTS system. The development cost of this system has been minimized by using hardware and software components from parallel Navy and NASA programs.

FY 1997 Milestones	Planned Date
1. Real Time Target Processing Demonstrated	06/01/97
2. Data Fusion and Visualization Demonstrated	06/30/97
3. Chemical Analyzer and Sediment Sampler Completed	06/01/97
4. System Integration and Tests Completed	08/15/97
5. Technology Demonstration	09/30/97
6. Data Analysis and Report	12/31/97

PROJECT SUMMARY

PROJECT TITLE & ID: Joint US/Germany In-Situ Bioremediation Demo; CU-99

RESEARCH CATEGORY: 6.3 Advanced Development

LEAD AGENCY: U.S. Air Force

LAB: Armstrong Laboratory - Tyndall Air Force Base, FL

PRINCIPAL INVESTIGATOR: Capt. Paul Devane

FY 1997 FUNDS: $100K

OBJECTIVE: The goal of this project is to conduct a field demonstration of bioventing and natural attenuation of a POL storage area contamination site at Rhein-Mein AB, Germany. The results generated from this field project will assist in successfully transferring these technologies to the German regulatory authorities and the German environmental consulting firms working on US military base clean-up activities in Germany.

TECHNICAL APPROACH AND RISKS: The US contractor is fully responsible for all aspects of the effort; design, construction of the experimental plots/areas, outfitting with the necessary hardware and monitoring equipment, implementation, monitoring, sampling, and analysis. This is a two-year demonstration. In this year, we will be doing monitoring and sample collection and analysis of the systems installed in the field. The technical risk is low for this effort. Our experimental plan provides enough flexibility to allow for collaborations with a German contractor. The technology gained from the field demonstration will transfer to HQ USAFE/CEV, HQ USAREUR, and contractors performing site cleanups at Air Force installations in Europe.

ACCOMPLISHMENTS: Conducted field demonstrations in FY 1996 of bioventing and natural attenuation so that these strategies will be accepted as proven technologies by German regulatory agencies and may be subsequently implemented to clean up fuel spills at DoD installations in Germany. Performance monitoring of the two systems will continue in FY 1997.

BENEFIT: These low-cost technologies will save the U.S. and German governments millions of dollars per contaminated site over conventional cleanup technology. The key outcome of this demo will be performance and cost information to prove to the Germaarbon-contaminated aquifer material at U.S. bases in Germany.

Appendix A

FY 1997 Milestones	Planned Date
1. Performance Monitoring of System	08/01/97
2. Final Soil Sampling Event	08/15/97
3. Final Report	09/25/97

PROJECT SUMMARY

PROJECT TITLE & ID: Permeable Reactive Barriers for In-Situ Treatment of Chlorinated Solvents; CU-107

RESEARCH CATEGORY: 6.3 Advanced Development

LEAD AGENCY: U.S. Air Force

LAB: Armstrong Laboratory - Tyndall Air Force Base, FL

PRINCIPAL INVESTIGATOR: 1Lt Dennis O'Sullivan

FY 1997 FUNDS: $950K

OBJECTIVE: Pump-and-treat technology contains contaminant plumes and removes dissolved-phase contamination in relatively homogeneous geologic formations. As a result of the slight solubility of the contaminant into the surrounding groundwater, and sorption to aquifer materials during transport, pump-and-treat processes require the treatment of massive amounts of water to remove relatively little contamination. Estimates of the duration of pump-and-treat necessary to fully remediate contaminated sites range from decades to centuries. In consequence, the cost of pump-and-treat treatment is extremely high. A newly-developed process, called the funnel-and-gate, is an in-situ technique that directs contaminated groundwater under passive flow through an engineered subsurface region for decontamination. While this process might not reduce the duration of treatment, once installed, it will operate with little or no operations and maintenance (O&M) investment, resulting in 50 percent savings over the life of the project. It is estimated that the use of this technology could result in a total savings of $1 billion.

The main objective of this project is the testing of alternative media at a field-scale, proof-of-principle demonstration. Two or three reactive media will be field-tested to compare their dechlorination potentials. Another objective is to concurrently develop a field-tested permeable barrier design protocol for in-situ remediation of chlorinated solvents in groundwater that would be acceptable to state and federal regulators.

TECHNICAL APPROACH AND RISKS: This project involves the field testing of two or three reactive media in a funnel-and-gate demonstration at Dover AFB, DE, and may involve innovative emplacement methods to reduce the construction costs of permeable barrier systems. A critical component of the project involves AL/EQ and US EPA NERL participation in the Remediation Technologies Development Forum (RTDF) Permeable Barriers Working Group (PBWG). This RTDF working group is a consortium of industry, government, and academic partners who share the common goal of developing more effective, less costly permeable barrier treatment technologies. The design protocol will incorporate results and tools previously developed under this project including the PC-based

GROWFLOW groundwater flow model, RACER cost estimating module, and process research for various media. Components of the protocol include: hydraulics modeling; cost estimation; media selection; column studies; longevity studies; emplacement methods; performance monitoring; analytical methods; and data management. Column studies and longevity tests will be performed to evaluate the performance of several candidate reactive media. Results from these studies will be used to determine the most appropriate media to incorporate into the pilot-scale field test.

The four main technical risks associated with this project relate to the performance of the reactive media. First, and foremost, is that long-term performance of reactive media under field conditions is unknown. Therefore, the actual life of the barriers might not match the design life. The second technical risk involves degradation of the reactive media. Previous laboratory column tests indicate precipitation and biofouling might occur in the reactive media. The third technical risk is that incomplete dechlorination might occur within the media.

ACCOMPLISHMENTS: In FY 1996, final reports on hydrodynamic modeling were completed and a cost module was developed for inclusion in the Remedial Action Cost Engineering and Requirements (RACER) system (version 3.2). Laboratory screening tests were completed on reactive media and apparatus was constructed to allow field column studies to be performed. A site has been selected at Dover AFB to perform a field demonstration in FY 1997, which will investigate several reactive media components and innovative emplacement methods for the permeable wall to optimize hydraulic capture and treatment of the plume.

BENEFIT: Many contaminated sites currently undergoing pump-and-treat remediation are expected to be tractable to funnel-and-gate configurations. With no active pumping involved in the process, these systems may be installed at sites for which power utility installation is a formidable obstacle to installation of pump-and-treat systems. The design protocol will be a tool available for DoD restoration project managers to use for designing barriers for other installations/hydrogeologic conditions. This document will also facilitate regulatory acceptance of this technology.

FY 1997 Milestones	Planned Date
1. Design Proof-of-Principle field demonstration incorporating data from other "reactive wall" sites into the design	03/01/97
2. Begin Proof-of-Principle field demo installation	08/01/97
3. Review/assist in development of performance monitoring for ESTCP pilot investigation at Moffet Field, CA	08/01/97
4. Interim Report	10/01/97

PROJECT SUMMARY

PROJECT TITLE & ID: Trichloroethylene Risk Assessment; CU-115

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: U.S. Air Force

LAB: Armstrong Laboratory - Wright Patterson Air Force Base, OH

PRINCIPAL INVESTIGATOR: Dr. Jeffrey W. Fisher

FY 1997 FUNDS: $750K

OBJECTIVE: The goal of this research is to present the US EPA with an alternative TCE risk assessment which replaces non-scientific policy assumptions with science-based evaluation.

Trichloroethylene (TCE) is among the top-ten priority groundwater contaminants within the DoD and nationally, and is present at over 39 percent of Superfund sites. The current required cleanup level in groundwater is low (5 ppb), with compliance costs estimated at billions of dollars. A typical stripping tower operation costs over a million dollars annually to operate, with an expected 15-20 year duration. Required cleanup levels are based on a risk assessment paradigm that includes significant policy-driven assumptions and safety factors. This leads to substantial uncertainty regarding the correlation between the cleanup level and cost-effective protection of human health.

Currently, all carcinogens are evaluated by the US EPA on the basis of assumptions made for mutagenic chemicals but scientific opinion places TCE in a different class of carcinogens: promoters. However, draft revised USEPA Guidelines for Cancer Risk Assessment are based on the premise that each chemical should be evaluated based on the "weight of evidence rather than using a standard approach to all chemicals." They state that "assumptions are to be displaced by facts or better reasoning when appropriate data are available." This project will greatly broaden the TCE research data base and incorporate innovative, probabilistic risk assessment approaches. Reevaluation of TCE based on its activity as a promoter, not a mutagen, can reasonably be assumed to result in a remediation level significantly greater than 5 ppb.

TECHNICAL APPROACH AND RISKS: Research areas include: mode of action of TCE (tumor promotion versus mutation); distribution of TCE & metabolites within the body (pharmacokinetics); physiologically-based pharmacokinetic modeling (including cross-species extrapolation); and probabilistically-based risk assessment. While focusing primarily on mouse liver tumors (the driving factor in the current risk assessment), studies will also explore reported kidney and lung tumors. In addition to low-level controlled human exposure studies, emphasis will be given to the use of in-vitro systems which permit the

study of rodent and primate/human tissue under the same conditions. This data will be very useful in making scientifically based, cross-species comparisons. A robust model of TCE metabolism in the mouse will then be altered by inclusion of human parameters and used to predict human effects.

ACCOMPLISHMENTS: In FY 1996, this project focused on development of state-of-the-art methodology and supporting data for extrapolation of toxicological findings in rodents to humans.

BENEFIT: Because the current remediation level (5 ppb) is extremely difficult to achieve, remediation costs are very sensitive to even small changes in this level. Revised TCE remediation goals, which are the likely result of an updated EPA risk assessment, will have a major impact on TCE remediation costs. New remediation goals will make this a dual-use technology with extensive application in the civilian sector.

FY 1997 Milestones	Planned Date
1. Complete TCA/DCA tumor comparison	11/01/96
2. Complete feasibility study of TCE Non-cancer endpoint	11/01/96
3. Submit TCE 60 day biological effect paper for pub.	11/01/96
4. Submit oral TCE mouse P-450 pathway modeling paper for pub.	11/01/96
5. Complete rodent Inhalation study and modeling	01/01/97
6. Submit P-450 metabolite IV paper for pub.	02/01/97
7. Complete human TCE P-450 pathway modeling and submit paper for publication	02/01/97
8. Complete rodent Inhalation modeling and submit paper for publication	03/01/97
9. Complete TCE/Chloroacetate tumor comparison	04/01/97
10. Complete Human sample analysis for glutathione	05/01/97
11. Complete TCE glutathione pathway study in rats	07/01/97
12. Complete lung metabolism study	09/01/97
13. Complete Modeling of TCE glutathione pathway	09/01/97
14. Submit cross-species comparison/extrapolation paper for publication	10/01/97
15. Final Report to SERDP	11/30/97

PROJECT SUMMARY

PROJECT TITLE & ID: Bioremediation of Hydrazine; CU-118

RESEARCH CATEGORY: 6.3 Advanced Development

LEAD AGENCY: U.S. Air Force

LAB: Armstrong Laboratory - Tyndall Air Force Base, FL

PRINCIPAL INVESTIGATOR: Mr. Jim Hurley

FY 1997 FUNDS: $50K

OBJECTIVE: Numerous industries use hydrazine fuels on a daily basis. The USAF and NASA utilize the fuels as a high energy missile and rocket propellant. However, hydrazine usage is not isolated to the DoD and NASA. Numerous civilian companies use hydrazine in boiler rooms as a corrosion inhibitor, in the manufacture of agricultural chemicals, and in the development of pharmaceuticals. The primary objective of this project is to discover, develop, and optimize a cost-effective environmentally conscious, and biologically mediated process for the remediation of hydrazine disposal and spill response techniques/options.

TECHNICAL APPROACH AND RISKS: The biocatalyst, diazoluminomelanin (DALM), has been selected for the remediation of hydrazine. DALM is a synthetic melanin, humic substance isolated from bacterial cell walls. The material, which is resistant to breakdown, is a free radical generator. The free radicals will be utilized in the destruction of residual hydrazine following a hydrazine spill. Remediation process scale-up and refinement will be conducted in the laboratory. Hydrazine environmental fate-and-transport studies will help identify and quantify hydrazine breakdown products once the fuels are introduced into the environment. Toxicology studies will reveal the biological effects of hydrazine degradation products as a result of natural environmental breakdown and the proposed remediation process (DALM). The toxicology studies will also serve as a risk assessment tool, assuring that we are not generating more toxic contaminants into the environment. The effective range (i.e., concentration, condition) of the biocatalyst poses a technical challenge to the research team. A controlled release study will be done at Dover AFB at the GRFL facility, which is part of the DoD NETTS program.

ACCOMPLISHMENTS: Toxicology and transport studies commenced in FY 1996 to ensure that degradation products are not harmful to the environment and to determine on a risk basis the effective range of biocatalyst that can be used during cleanup. These studies will be completed in FY 1997.

BENEFIT: As a result of this research and development endeavor, a biologically mediated process for the in-situ remediation of hydrazine contamination will be developed. The

technique will fully satisfy the USAF's need for a cost-effective and environmentally sound hydrazine degradation process. The remediation technique can potentially be applied to the remediation of other environmental contaminants.

FY 1997 Milestones	Planned Date
1. Initiate Toxicology Studies	03/01/96
2. Initiate Transport Studies	03/01/96
3. Complete Toxicology Studies (Report)	10/01/96
4. Complete Transport Studies (Report)	12/01/96

PROJECT SUMMARY

PROJECT TITLE & ID: Aquifer Restoration by Enhanced Source Removal; CU-368

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: U.S. EPA

LAB: National Risk Management Research Lab - Ada, OK

PRINCIPAL INVESTIGATOR: Dr. Carl Enfield

FY 1997 FUNDS: $1,020K

OBJECTIVE: Low-solubility organics such as chlorinated solvents were used and released to the environment in massive quantities during the 1950s, 1960s, and 1970s. These contaminants have migrated through the subsurface and entered groundwater at over 1,000 DoD sites. At these sites, the organic contaminants are found in one of four phases: (1) volatilized within the soil's vadose zone (vapor phase), (2) dissolved in the ground water (dissolved phase), (3) sorbed to the aquifer solids (sorbed phase), or (4) as a separate non-aqueous phase liquid (NAPL phase), consisting of light and dense non-aqueous phase liquids (LNAPL and DNAPL). All of these contribute to the contamination and need to be removed.

The limiting factor to satisfactory remediation at over 75 percent of the hazardous waste sites in the United States is restoration of ground-water quality. The major limitations to the successful use of pump-and-treat technology are related to difficulties in extracting contaminants from source areas where NAPLs exist, especially DNAPLs. The objective of this research is to take extraction (solubilization and mobilization) science, which has been developed at bench scale, and evaluate its potential for enhancing extraction in the source area. Design manuals are to be developed and evaluated using field pilot-scale cells comparing technologies side-by-side.

TECHNICAL APPROACH AND RISKS: The proposed work will be a series of field demonstrations of enhanced pump-and-treat technologies supported by site characterization and laboratory research required to produce credible field demonstrations and evaluations. The work will focus on remediation of source areas of sites believed to be contaminated by non-aqueous phase liquids (NAPLs) at residual concentration (no longer mobile and, therefore, not available for extraction by pumping).

The processes will be demonstrated at different sites with different hydrogeology and different chemical mixtures (both NAPLs and sorbed contaminants will be considered) to determine their performance under a variety of conditions. The tests will be conducted as controlled, small-scale field projects. Each technology will be compared with one or more

alternative remediation technologies including conventional pump-and-treat as a reference treatment system. The results of these comparisons will show the differential improvement achieved by one process relative to another. A manual will be prepared for the user community to permit design of these systems. The design manual will contain anticipated system performance. Success will be dependent on: the ability to obtain access to actual sites; obtaining regulatory permission to perform non-standard, pilot-scale evaluations without significant delay; and maintaining continuity of funding throughout the project.

ACCOMPLISHMENTS: Field work at a site at Hill AFB contaminated with fuels and other LNAPLs such as fire-training chemicals and dumped organic chemicals was concluded in FY 1996. Tests, which took place in hydraulically isolated cells so that mobilized contaminants could be collected in extraction wells, showed that alcohol could be used to remove 80 percent of all contaminants (and 100 percent of some) in a two-week period and that capture of released contaminants was achieved.

BENEFIT: It is estimated that over 90 percent of the contaminants in the subsurface environment is contained in the source area. Until the source area is identified and remediated or contained, it will not be possible to obtain a permanent closure for any of the sites. Pump-and-treat systems are the primary technology in use at sites with contaminated ground water. Because of their inability to effectively clean source regions of contaminated waste sites, many of them will be operated "in perpetuity". The cost of operating and maintaining these systems is enormous, and the institutional arrangements to keep them operating for tens to hundreds of years do not exist. Bench-scale studies suggest that it will be possible to remove the majority of the NAPL where the source can be identified. The time required for this removal is small compared to the time required if pump-and-treat technologies are used. Estimated costs for groundwater remediation by DoD and other Federal Agencies range upward of hundreds of billions of dollars, and even incremental improvements in efficiency will justify the cost of the proposed research.

FY 1997 Milestones	Planned Date
1. Interim LNAPL Report cosolvent solubilization	02/11/97
2. Interim LNAPL Report surfactant solubilization	03/14/97
3. Interim LNAPL Report cosolvent mobilization	04/11/97
4. Interim LNAPL Report steam	05/12/97
5. Interim LNAPL Report cyclodextrin	05/12/97
6. Interim LNAPL Report surfactant mobilization	06/11/97
7. Interim LNAPL Report sparging	06/11/97
8. Interim LNAPL Report in well aeration	06/11/97
9. Initiate field studies for DNAPL Site	07/01/97

PROJECT SUMMARY

PROJECT TITLE & ID: Removal of VOCs from Contaminated Groundwater and Soils by Pervaporation; CU-371

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: Environmental Protection Agency

LAB: National Risk Management Research Lab - Cincinnati, OH

PRINCIPAL INVESTIGATOR: Dr. Subhas K. Sikdar

FY 1996 COMPLETED PROJECT

OBJECTIVE: To investigate the feasibility of using membrane pervaporation as the ex-situ component of an integrated pump-and-treat process.

BENEFIT: Surfactant flushing has been proposed to enhance the removal of VOCs from the groundwater or soil matrix in pump-and-treat processes (see project **CU-368**). However, the resulting recovered oil-water emulsion is difficult to break, which adds cost to its disposal or treatment. Pervaporation, in which volatile components of an aqueous stream sorb on to a non-porous membrane, permeate through it, and evaporate on the outside, is a means of breaking the emulsion while separating concentrated VOCs from the contaminated water, and allowing recycle of the surfactant.

ACCOMPLISHMENTS: Prototype tests were conducted in FY 1996 at the US EPA's National Risk Management Research Laboratory in Cincinnati, OH and at Northeast Hazardous Substance Research Center, New Jersey Institute of Technology to evaluate the performance of the prototypes at various levels of standard surfactant, and with a recovered surfactant/alcohol solution from field trials of an enhanced source removal technique at Hill AFB, UT. Both commercial, spiral-wound and innovative, hollow- fiber membranes were evaluated. Better than 94 percent removal of various chlorinated solvents was obtained.

TRANSITION: This technology will transition into the ESTCP program in FY 1997 while field tests are planned at the GRFL at Dover AFB where coordination with project **CU-368** is planned. The pervaporation process is protected by an invention disclosure at EPA.

PROJECT SUMMARY

PROJECT TITLE & ID: National Environmental Technology Test Sites (NETTS) Program — Consortium for Site Characterization Technology; CU-374

RESEARCH CATEGORY: 6.4 Demonstration and Validation

LEAD AGENCY: Environmental Protection Agency

LAB: National Exposure Research Laboratory - Las Vegas, NV

PRINCIPAL INVESTIGATOR: Dr. Stephen Billets

FY 1997 FUNDS: $25K

OBJECTIVE: The goal of this project is to evaluate, and report on innovative and alternative monitoring, measurement and site characterization technologies in support of the DoD NETTS program. This will facilitate the acceptance and use of cost-effective technologies applicable to a wide range of environmental problems, particularly focusing on hazardous waste site assessment, characterization, and monitoring. There is a clear need to ensure that better, faster, and less expensive technologies are available for cleaning up Installation Restoration Program (IRP) and Base Realignment and Closure (BRAC) sites. Achieving cost-effective site cleanup is in everyone's best interest. However, currently there is a long lag time between the successful field demonstration of a new technology and its routine use. This will likely continue unless a concerted effort is made to advance innovative and emerging technologies. It is also apparent that without active involvement by EPA, the emergence and use of new technologies will continue only slowly. An objective of this demonstration program is to facilitate acceptance by regulators and to develop a data base of information relating to these new technologies.

TECHNICAL APPROACH AND RISKS: NERL, CRD-LV supports the DoD NETTS program by providing planning support for the demonstration of site characterization technologies developed by SERDP or other technology development sponsors (where the technology can be used to support a DoD requirement). We are also responsible for producing guidance on how to conduct and evaluate these types of technologies; providing support to the other National Test Locations Managers in conducting demonstrations; and for managing and disseminating information on demo encountered during the project: lack of sufficient staff and resources to handle demonstrations of all the SERDP-sponsored characterization technologies, disruption of on-going demonstration while waiting for funding, and delays in receiving approval of technologies for demonstration (non-SERDP derived).

ACCOMPLISHMENTS: In FY 1996, the SERDP Program Office issued programmatic guidance and standardized test protocols for researchers considering demonstrations at NETTS facilities. A marketing plan for the test locations to ensure that other government

and privately-sponsored technology developments can take advantage of the NETTS facilities was drafted, and a technology transfer strategy for completed successful demonstrations was produced. Many completed NETTS demonstrations graduate into the ESTCP program. A cost-and-performance database to serve as a repository of results from completed demonstrations was also designed.

BENEFIT: Savings in site cleanup will reduce the need for new or additional federal taxes to support federally funded cleanups. Lower costs for cleanups funded by private parties should reduce inflationary pressures. The NETTS demonstration program will provide a central conduit to channel new technologies to the marketplace more expediently than current methods. Investment capital should be easier to obtain because the developer will have a technology acceptance road map to show to investors. The focus of this project is to support the use and implementation of new technologies by rapidly introducing them to the user community through training, field trial, and direct application at current sites. This demonstration activity is designed to: maximize information transfer and reduce duplication; provide assistance to public and private sector users and developers; support the diffusion of technologies derived from basic and applied R&D programs; and be a collaborative effort.

FY 1997 Milestones	Planned Date
1. Information Transfer of Technology Evaluation Reports	11/01/97
2. Interim Report	12/30/97

PROJECT SUMMARY

PROJECT TITLE & ID: Subsurface Bioremediation Process Monitoring Indicators; CU-383

RESEARCH CATEGORY: 6.3 Advanced Development

LEAD AGENCY: Environmental Protection Agency

LAB: National Risk Management Research Laboratory - Ada, OK

PRINCIPAL INVESTIGATOR: Dr. Candida C. West

FY 1996 COMPLETED PROJECT

OBJECTIVE: Fuel Hydrocarbon contamination of soil and groundwater at DoD facilities has been a common problem due to activities related to the use and maintenance of military vehicles and aircraft. The objectives include identification of major transformation conditions and pathways, mass distributions of both source-related compounds and metabolic products, and the spatial and temporal variability in these distributions which bear on the extent of bioremediation efficiency. The results will provide recommendations on monitoring criteria to be used for bioremediation efficacy evaluation. The monitoring indicators are being validated at Wurtsmith AFB, a DoD SERDP National Environmental Technology Test Sites.

BENEFIT: The project resulted in a conceptual model which might reduces the number of sampling wells required at a contaminated site, reduces uncertainties in contaminant distribution, and provides increased cost-effectiveness of indigenous bioremediation of fuel hydrocarbons. Also, subsurface process monitoring indicators have been developed to identify major inorganic and organic parameters that serve as yardsticks for bioremediation activity, especially for fuels. This monitoring capability will result in substantial cost savings in the traditional remediation monitoring activities. Conservative savings are 20-25 percent.

ACCOMPLISHMENTS: Monitoring of soil and groundwater samples at the site of a tanker aircraft crash were conducted throughout FY 1996. In-situ microcosms were also installed. Based on comprehensive analysis of available site characterization data, inorganic and organic geochemical conditions, and geomicrobiological markers, in-situ biodegradation has occurred in the aquifer. Horizontal and vertical profiles of aromatic hydrocarbons, aromatic acids, and phospholipid ester-linked fatty acids in aquifer solids suggest that microbially mediated oxidation-reduction reactions were responsible for the degradation of hydrocarbons.

TRANSITION: Continued monitoring of the site, together with long-term cell toxicity testing to indicate the impact of intermediate fuel hydrocarbon breakdown products, will be undertaken by the National Center for Integrated Bioremediation Research and Development (NCIBRD).

PROJECT SUMMARY

PROJECT TITLE & ID: Removal and Encapsulation of Heavy Metals from Ground Water or Soil Extract; CU-387

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: Environmental Protection Agency

LAB: National Risk Management Research Lab - Cincinnati, OH

PRINCIPAL INVESTIGATOR: Dr. Subhas K. Sikdar

FY 1996 COMPLETED PROJECT

OBJECTIVE: To develop high-capacity, low-cost sorbents for separation of heavy metals from groundwater, and a polymer system for encapsulating these sorbents.

BENEFIT: The process could be applied as an ex-situ component of a pump-and-treat system or as a permeable barrier in a funnel-and-gate system. Higher concentrations of recovered contaminant are possible with polymer encapsulation compared to concrete. Metal resource recovery is also a potential benefit of this process.

ACCOMPLISHMENTS: In FY 1996, bench scale sorption tests were completed on contaminated-soil extracts from two U.S. Army sites. Zeolite demonstrated the highest removal capacity of the sorbents tested. Equipment for mixing the sorbent with polyethylene and subsequent processing were also evaluated.

TRANSITION: The project will conclude early in FY 1997 with an evaluation of polymer durability and the process will be transitioned to a private partner for commercialization.

PROJECT SUMMARY

PROJECT TITLE & ID: Subsurface Gas Flowmeter; CU-404

RESEARCH CATEGORY: 6.3 Advanced Development

LEAD AGENCY: Department of Energy

LAB: Sandia National Laboratory - Albuquerque, NM

PRINCIPAL INVESTIGATOR: Dr. Sanford Ballard

FY 1996 COMPLETED PROJECT

OBJECTIVE: To design a subsurface gas flowmeter for effectively monitoring remediation processes involving nutrient gas injection or soil gas extraction, and to control flow, improve efficiency, and assess zones of influence in these processes.

BENEFIT: The subsurface gas flowmeter has been designed to measure the full three-dimensional air flow velocity vector in dry sediments. It is based on the principle that the temperature distribution on the surface of a finite length, heated cylinder buried in a permeable flow field is related to the flow velocity of the fluid flow past the cylinder.

ACCOMPLISHMENTS: A subsurface gas flowmeter was developed to address the need to directly measure gas flow velocities in saturated permeable media. In FY 1996, prototype flowmeters were built and tested both in laboratory tanks and in field settings. A suite of flowmeters was installed at a remediation site where hydrocarbons are being removed from the water table by a combination of air sparging and soil vapor extraction.

TRANSITION: This technology will be licensed to a private company for commercialization.

PROJECT SUMMARY

PROJECT TITLE & ID: Biosorption Treatment of Plasticizers and Solvents; CU-711

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: U.S. Army

LAB: Waterways Experiment Station - Vicksburg, MS

PRINCIPAL INVESTIGATOR: Ms. Cynthia L. Teeter

FY 1996 COMPLETED PROJECT

OBJECTIVE: To develop a treatment process using organophilic clay (OPC) for groundwaters contaminated with chlorinated solvents and other VOCs at low levels that are not efficiently removed by conventional treatment. OPC is used for performance comparison with granular activated carbon (GAC) for low level contaminants such as TCE.

BENEFIT: A treatment technology capability that utilizes an OPC for bioremediation treatment for low level contaminants such as TCE. This provides availability of another cost-effective remediation process option.

ACCOMPLISHMENTS: The process utilizes an organophillic clay to absorb and concentrate contaminants prior to cometabolic, microbial destruction in an aerobic bioslurry reactor. Results from laboratory-scale feasibility tests and kinetic studies were incorporated into the design of a mobile pilot-scale system. Initial pilot trials were conducted at the U.S. Army Cold Regions Research and Engineering Laboratory (CRREL) with encouraging results. Documentation of this process as well as field manual for field demonstration of this technology is almost complete.

TRANSITION: The mobile unit is now available for field demonstrations at other DoD sites.

PROJECT SUMMARY

PROJECT TITLE & ID: Enhancing Bioremediation Processes in Cold Regions; CU-712

RESEARCH CATEGORY: 6.1 Basic Research

LEAD AGENCY: U.S. Army

LAB: Cold Regions Research and Engineering Laboratory - Hanover, NH

PRINCIPAL INVESTIGATOR: Dr. Charles M. Reynolds

FY 1996 COMPLETED PROJECT

OBJECTIVE: To develop rhizosphere-based remediation systems, which exploit the enhanced microbial activity in the rhizosphere (the area of soil surrounding plant roots) by growing plants on fuel-contaminated land and supplementing with nutrients.

BENEFIT: Enhanced rhizosphere biotreatment has tremendous potential for low-cost soil treatment to overcome the limitations to the application of conventional bioremediation in cold climates or remote regions. Cost savings using rhizosphere- enhanced biotreatment compared to using conventional remediation techniques in similar environments can be significant and conservatively estimated to be 10 fold.

ACCOMPLISHMENTS: One season of a field experiment in Alaska, which showed enhanced degradation of diesel, was completed in FY 1996. Researchers successfully demonstrated enhanced rhizosphere biotreatment for heavy petroleum compounds such as pristane, phytane, diesel and crude oils in the laboratory with corroborating field results at Fort Wainwright.

TRANSITION: The technology will be transferred to other field sites in Arctic and sub-Arctic regions through ongoing reimbursable projects, and later, planned to be transferred to ESTCP for full-scall field demonstration.

PROJECT SUMMARY

PROJECT TITLE & ID: Explosives Conjugation Products in Remediation Matrices; CU-715

RESEARCH CATEGORY: 6.1 Basic Research

LEAD AGENCY: U.S. Army

LAB: Waterways Experiment Station - Vicksburg, MS

PRINCIPAL INVESTIGATOR: Dr. Judith Pennington

FY 1997 FUNDS: $240K

OBJECTIVE: During investigations of potential treatment technologies for explosives-contaminated soils, specifically during bioslurry treatability studies and composting, TNT has been observed to interact with some component of the treatment matrix in such a way as to preclude extraction with organic solvents. Similar interactions have been observed in explosives-amended soils: mass balance determinations using radio-labeled TNT reveal that the radioactivity is still present in the matrix in some unknown form. As much as 80 percent of the radioactivity added to tests is accounted for in the unextractable matrix. Therefore, the parent compound has not been completely destroyed, but has changed to a more complex form. The long-term stability and environmental safety of these uncharacterized conjugates are unknown. Objectives of this basic research include characterization of these explosives conjugates, development of an analytical methods for identifying them in treatment systems and in soils, and determining the long-term stability and environmental safety of the conjugates. Accomplishment of these objectives will ensure the development of effective remediation technologies that ameliorate environmental health effects and lead to a more complete characterization of the end products of new treatment technologies. Research was initiated to determine the basic mechanisms of interactions between TNT and humus, soil enzymes and clays under SERDP in FY 93. This proposed research would expand upon that effort.

TECHNICAL APPROACH AND RISKS: The ability of explosives to form conjugates with soil organic fractions (i.e. humic acids, fulvic acids, and enzymes such as peroxidase, laccase, and tyrosinase), clays (i.e. montmorillonites and kaolinites), and other mineral components of remediation matrices (i.e. oxy/hydroxy compounds of iron and other minerals) will be evaluated. The influence of environmental factors such as temperature, pH and moisture regimes on development and characteristics of conjugates will also be determined. Classical extraction and analytical techniques have been ineffective in removing and describing these unextractable conjugates. Therefore, innovative analytical techniques will be applied. The role of microbial processes in conjugation of explosives to microbial cell walls will be investigated. Factors affecting stability of the conjugates to leaching and microbial degradation will be determined. Characterization of the ecotoxicology of conjugates will

answer the question of whether conjugates are environmentally compatible. The potential for reappearance of toxicity from re-release of parent compound or from the formation of toxic metabolites will be investigated. Microbial mutagenic and cultured cell line in vitro assays, and whole organism adult and early life-stage bioassays will be used. The influence of environmental factors on bioavailability and on the time course of toxic potency will be determined. Compost material from a DoD NETTS site will be tested if available.

ACCOMPLISHMENTS: Degradation studies using microbial isolates cultured from composting experiments were conducted in FY 1996. These studies were made possible by modifying analytical procedures which allowed dramatic improvement in recovery of TNT transformation products. Results to date indicate that conjugates result from several processes occurring in the matrix. Some of these processes are potentially reversible while others are more stable. Bioassays are also being conducted to determine toxicity.

BENEFIT: The DoD places a high priority on development of truly effective remediation technologies for explosives-contaminated soils and groundwater. Nevertheless, most current technologies fail to demonstrate complete destruction of explosives. Rather, explosives are transformed to related conjugation products that are recalcitrant to further characterization. Although these products are suspected of being relatively unavailable for transport or toxicity in the short term (weeks to months), their ultimate fate in the long term (years) is unknown. This lack of understanding of the ultimate fate of explosives severely limits the credibility of certain remediation technologies. This study will improve existing and future remediation technologies by identifying the types of chemical bonding and potential environmental impacts of explosives conjugates in remediation matrices. Acceptance of remediation technologies will be enhanced with regulatory agencies and other users concerned with the ultimate safety and environmental effects of explosives. Furthermore, an understanding of the nature and properties of conjugation products will lead to new and improved approaches to remediation.

FY 1997 Milestones	Planned Date
1. Conduct whole organism and early life-stage bioassays (WES)	12/31/96
2. Identify factors controlling biodegradation of conjugates (WES)	06/30/97
3. Determine precision and accuracy of analytical methods in various matrices (CRREL)	09/30/97
4. Interim Report	11/30/97

PROJECT SUMMARY

PROJECT TITLE & ID: Federal Integrated Biotreatment Research Consortium: Flask to Field Initiative; CU-720

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: U.S. Army

LAB: Waterways Experiment Station - Vicksburg, MS

PRINCIPAL INVESTIGATOR: Mr. Jeffrey W. Talley

FY 1997 FUNDS: $2,150K

OBJECTIVE: The objective of this project is to develop "realistic" biotreatment processes for cleanup of several classes of contaminants at DoD sites. A single, panacea technology for each contaminant group that can be used at all DoD sites will not be obtained. All treatment processes have technical and economic limitations. Part of the experimental process of this program will be to define these limitations. We plan to offer the DoD community a biotreatment "toolbox" that can be drawn upon to offer the right process for each site.

TECHNICAL APPROACH AND RISKS: The technical approach will be to investigate a variety of promising biotreatment processes at the bench and intermediate scale that have potential for being fielded within a reasonable amount of time. This approach will ensure that the DoD will have more cost-effective remediation technology at its disposal within a time-frame that will allow DoD to utilize them during its efforts at site remediation. The research in this program will be directed toward four major contaminant groups: explosives, chlorinated solvents, polychlorinated biphenyls (PCBs), and higher polycyclic aromatic hydrocarbons (hPAHs).

Issue I. Biotreatment of Explosives-Contaminated Soils and Groundwater

a. Enzymatic degradation performed in a variety of controlled systems. Controlled enzyme manufacturing methods will also be investigated.
b. The use of specialty surfactants, both manufactured and natural, will be evaluated for their ability to enhance the bioavailability of explosives compounds to microbial populations during treatment.
c. The metabolic pathways and biodegradation of key intermediates.
d. Alternating redox conditions and techniques for establishment of either condition within an active bioreactor system.
e. The use of genetically altered microorganisms as reactor seeds.

Issue II. Soils Contaminated with hPAHs

a. Surfactants, both natural and manufactured, for enhancing biodegradation rate in a variety of biotreatment systems.
b. Evaluation of candidate cometabolites for initiating and economically maintaining effective hPAH biodegradation rate.
c. Use of genetically altered organisms for enhancing biodegradation.
d. Cascading aerobic bioslurry treatment.
e. Composting techniques for degradation of highly complex HPAH-contaminated matrices.
f. Evaluation of the activity of various natural isolates and consortia toward HPAHS under a variety of implementation scenarios.

Issue III. Soils and Groundwater Contaminated with Chlorinated Solvents

a. Bioventing of chlorinated solvents using aliphatic oxygenase pathways via addition of simple aliphatic gases (i.e., propane, methane, etc.).
b. Evaluation and modeling of enzyme production and substrate interactions.
c. Anaerobic biodegradation in aqueous and soil phase systems.
d. The impact of co-distributed solvents on biodegradation rate.
e. Bioslurry treatment using process air recirculation.

Issue IV. Soils and Sediments Contaminated with PCBs

a. Degradation and production kinetics of enzyme-based degradation.
b. Cycling of redox conditions from anaerobic to aerobic as a means of dechlorinating higher substituted Aroclors into lower substituted, easier to degrade Aroclors.
c. Use of surfactants, both natural and manufactured, as a means of enhancing bioavailability during biological treatment.
d. An evaluation of candidate cometabolites for enhanced degradation of selected PCB Aroclors.
e. Use of genetically-altered microorganisms as potential seed sources.
f. The impact of other co-distributed contaminants, such as petroleum hydrocarbons, on PCB biodegradation.
g. Evaluation of various natural isolates and consortia toward PCB biodegradation using a variety of biotreatment systems.

Issue V. Design and Implementation Evaluation

a. Cascading bioslurry systems.
b. Improved process gas recirculation systems for treatment of contaminated media containing volatile compounds such as chlorinated solvents.
c. Development of biocells as an economically attractive reactor option.
d. Wetlands as biotreatment system.

e. Development of automated anti-foaming systems for bioslurry.
f. Development of barrier wall systems utilizing induced electrical potential.
g. Development of in-situ augmentation systems.

Issue VI. Applications Potential of Genetically-Engineered Microorganisms

Issue VII. Toxicity Reduction

Several promising processes for each contaminant will first be concurrently developed and evaluated on the bench scale for effectiveness toward numerous soil and groundwater samples collected from actual DoD sites contaminated with the compounds of interest on the strict basis of chemical analysis and degradative pathways mechanisms. Design evaluations will be initiated at this stage as a technology "reality check." Upon completion of the bench efforts, several small-scale, pilot studies ("intermediate" scale) will be performed for the most promising processes. Intermediate scale studies will be performed under controlled laboratory conditions to evaluate bench results, verify the scientific concepts, and provide initial cost estimates. Evaluations at this stage will be based on both chemical analyses and some toxicological assays. Another key observation made at this scale is the identification of process limitations and potential regulatory issues that may impede implementation such as process waste streams, safety hazards, or issues associated with the use of engineered organisms. After performance of the intermediate scale studies, at least one, possibly more, of the most economically and technically sound processes for that contaminant group will be evaluated on the field-pilot scale at actual DoD sites. During performance of all levels of activities, experienced engineers (e.g. the USACE, Baltimore District) will work with research scientists to assess the overall implementation potential and projected costs associated with these techniques. This effort will ensure that the research groups are developing processes that are economically realistic and on firm technical ground.

ACCOMPLISHMENTS: Accomplishments for explosives in FY 1996 were elucidation of the breakdown pathway and completion of fluidized bed reactor studies for TNT mineralization in contaminated groundwater. For explosives-contaminated soils, surfactants were shown to improve bioavailability . Phytoremediation also shows great promise for both TNT and RDX. The hydraulic retention time for constructed wetlands was determined and demonstrated in the field at Volunteer AAP (a DoD NETTS national test site). For chlorinated solvents, it was shown that placement of a metal coil or iron electrodes had the same beneficial effect on in-situ electrostimulated microbial reductive dechlorination of PCE in soils. However, the ex-situ gas recirculation reactor, which is appropriate for soils contaminated with semi-volatile organic compounds did not improve mineralization of the more volatile TCE contaminant. Improved bioavailabilty of PAHs through biologically-produced surfactants was achieved, and degradation pathways for fluoranthene and pyrene were determined. Improved microbial strains for PCB degradation have been developed although inhibition by an intermediate breakdown product has been identified as a bottleneck. Additionally, field demonstration of the biocell reactor design, which is a 10 cubic yard ex-situ reactor for

bioventing, commenced with remediation of marine-diesel-contaminated soil at the DoD NETTS National Test Site at Port Hueneme.

BENEFIT: Results to date have demonstrated significantly reduced time and cost benefits required for cleanup of contaminated DoD sites. One of the immediate benefits of this effort is the reduction in cost of remediating a 50,000 cubic yards site using a $200/cubic yard biotechnology as compared to a $400/cubic yard incinerator. This amounts to a cost savings of $10,000,000. Other benefits are the development of evaluation and design protocols for demonstration validation, increasing the number of acceptable contaminant destruction technologies, and a greater regulatory and public acceptance of new technologies.

FY 1997 Milestones	Planned Date
1. Establish Technical Advisory Committee	12/31/96
2. Characterize TNT-degrading microbial consortia	09/30/97
3. Evaluate Biocell treatment of contaminated soils in field	09/30/97
4. Evaluate Bioslurry treatment of contaminated soils in field	09/30/97
5. Characterize hPAH degradation pathways	09/30/97
6. Evaluate Biocell treatment of contaminated soils in field	09/30/97
7. Evaluate cascading bioslurry reactors	09/30/97
8. Incorporate constitutive strains into biotreatment systems	09/30/97
9. Evaluate engineering of electrolytic stimulation of PCE dechlorination	09/30/97
10. Evaluate phytoremediation of PCBs	09/30/97
11. Evaluate aerobic degradation of PCBs with new strains	09/30/97
12. Evaluate engineering of reductive dechlorination of PCBs (Moved to FY 1998 due to budget reduction)	09/30/97
13. End-of-Year Report	09/30/97

PROJECT SUMMARY

PROJECT TITLE & ID: National Environmental Technology Test Sites (NETTS) Program — Volunteer Army Ammunition Plant (VAAP); CU-723

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: U.S. Army

LAB: Army Environmental Center - Aberdeen Proving Ground, MD

PRINCIPAL INVESTIGATOR: Mr. A.J. Walker

FY 1997 FUNDS: $200K

OBJECTIVE: The U.S. Army's objective in the NETTS program is provide a NETTS National Test Location (NTL) to facilitate the demonstration and evaluation of cost-effective, innovative, environmental technologies focused on characterizing, remediating, or attenuating soil and groundwater at sites contaminated with explosives and related nitroaromatic compounds, and expedite the transfer of successfully demonstrated technologies to the user community for implementation in full-scale facility remediation efforts.

In order to achieve this objective, the U.S. Army Environmental Center, Environmental Technology Division (ETD), has established NTL infrastructure for on-site project management and field support at Volunteer Army Ammunition Plant (VAAP). To provide sites for demonstrating characterization and remediation of a broader spectrum of explosives, ETD selected Louisiana Army Ammunition Plant (LAAP) as a satellite test location. LAAP will offer a viable site for intrinsic remediation studies such as Natural Attenuation.

TECHNICAL APPROACH AND RISKS: There is a NETTS analytical laboratory on site at the VAAP NTL which is dedicated to technology demonstration analytical support. It provides expedient sample analysis and turnaround times, an effective platform for ensuring QA/QC, and significant cost savings compared to private analytical laboratories. During technology demonstrations cost and performance parameters for various environmental characterization and remediation technologies are monitored and recorded. Cost and performance data are collected for incorporation into the NETTS Cost and Performance Database. In this manner critical technology demonstration data can be accessed for further analysis and development or for incorporation into cleanup strategies where cost-effective and innovative techniques are sought.

BENEFIT: Substantial project time and cost savings will be realized through the provision of dedicated tests sites for technology demonstration. These benefits are realized through the provision of infrastructure, on-site field support and project administration and management support necessary to facilitate demonstration of environmental technologies. Infrastructure

support provided includes an established regulatory interface, current operating permits, on-site field support, in-place system for disposal of waste, and on-site analytical laboratory analysis. The immediate benefit of having dedicated test sites is that technology developers do not have to dedicate limited time and scarce resources to interfacing with regulators, obtaining permits, and identifying mechanisms for residuals disposal, and can thus concentrate their efforts on successful development and demonstration of their technologies under a rigorous and structured program.

Demonstration	Status
1. Advanced oxidation process for TNT-contaminated groundwater at VAAP using ozone with activated carbon absorption (private)	Completed FY 1996
2. Phytoremediation pilot study using TNT-contaminated groundwater at VAAP (CU-720)	Ongoing FY 1997
3. Ecological Biomarkers study to monitor impacts to wild fauna in TNT-contaminated area at VAAP (CS-244)	Completed FY 1996
4. Validation of SCAPS for in-situ measurement of explosives at VAAP (CU-729)	Planned FY 1997
5. Fluidized Bed aerobic reactor for explosives at VAAP (CU-866/720) (Armstrong Labs/ICIA CRADA)	Planned FY 1997
6. Natural Attenuation at Louisiana AAP (DERA/ESTCP)	01/15/97
7. In-situ treatment of nitroaromatics in groundwater using UVB groundwater circulation wells/bioreactor (private)	Planned FY 1997
8. Sequential biopile treatment of nitroaromatics and chlorinated organics in soil (private)	Planned FY 1997
9. Encapsulated microorganisms for bioremediation of nitroaromatics (private)	Planned FY 1997
10. Explosives detection using passive absorbent system (private)	Planned FY 1997
11. In-situ electrokinetic soil remediation (DOE/private)	Planned FY 1997

PROJECT SUMMARY

PROJECT TITLE & ID: Peroxone Treatment of Contaminated Groundwater; CU-726

RESEARCH CATEGORY: 6.3 Advanced Development

LEAD AGENCY: U.S. Army

LAB: Waterways Experiment Station - Vicksburg, MS

PRINCIPAL INVESTIGATOR: Ms. Elizabeth Fleming

FY 1996 COMPLETED PROJECT

OBJECTIVE: To determine performance limitations and provide a portable prototype Peroxone system, which is an advanced oxidation process that utilizes ozone and hydrogen peroxide to degrade explosives (such as TNT and RDX) and other groundwater contaminants but is less costly than UV-based systems.

BENEFIT: This project provides an advanced oxidation process for ex-situ remediation of organic groundwater contaminants, including explosives, with the potential for an order of magnitude cost savings over currently accepted best technology ($0.50/1,000 gallons versus $4.00-$5.50/1,000 gallons for activated carbon treatment). Considering the hundreds of millions of gallons of contaminated groundwater, Peroxone treatment has significant potential benefit to DoD, other federal agencies, and private industry. The Peroxone treatment process has been successfully used at the Cornhusker Army Ammunition Plant (CAAP) to clean the underground water contaminated with the highest concentration of TNT and RDX.

ACCOMPLISHMENTS: Test results have indicated nearly complete breakdown (below detection levels) of TNT and chlorinated solvents. In FY 1996, further research was conducted to elucidate the breakdown pathway for reduced nitro-aromatics, and refinements were made to the design of the pilot system. Another pilot plant study was conducted.

TRANSITION: An applications manual was completed for transition into the ESTCP program. A final pilot demonstration will be conducted early in FY 1997.

PROJECT SUMMARY

PROJECT TITLE & ID: Accelerated Tri-Services SCAPS Sensor Development; CU-729

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: U.S. Army

LAB: Waterways Experiment Station - Vicksburg, MS

PRINCIPAL INVESTIGATOR: Dr. Ernesto R. Cespedes

FY 1997 FUNDS: $2,050K

OBJECTIVE: The objective of this project is to accelerate the development, testing, and demonstration of new or enhanced sensor technologies for detecting and delineating subsurface contaminants in situ. This work will significantly expand the capability of the Site Characterization and Analysis Penetrometer System (SCAPS) to detect chemical contamination in soils and groundwater. Additionally, this project includes development of improved sampling, analysis, and data processing technologies to support the new or enhanced sensor technologies. Technology developed under this proposed effort will be transitioned to the U.S. Army Environmental Center (AEC) which is the agency responsible for demonstrating and transitioning SCAPS technologies to the U.S. Army Corps of Engineers District Offices, the Naval Facilities Engineering Command, the Air Force System Program Office (HSC/YAQ), and also to DOE-HQ. Transition of SCAPS technology to private industry will be pursued by licensing agreements for patented technology and through Cooperative Research and Development Agreements (CRADA).

TECHNICAL APPROACH AND RISKS: We will initially identify and evaluate candidate sensing technologies which address DoD, DOE, and EPA contaminants of interest and which have potential for rapid in-situ SCAPS applications. Laboratory instrumentation will be developed to determine limits of detection, define soil matrix effects, and evaluate SCAPS implementation considerations. Associated support technologies, including data acquisition, analysis, and visualization systems will be developed and tested. Prototype SCAPS sensor and sampler probes will be developed and tested in controlled laboratory and field experiments. SCAPS field tests and demonstrations will be conducted to validate SCAPS technologies and to increase acceptance by regulators, users, and the public. These field tests will make maximum use of available DoD NETTS test sites. Technical risks associated with this project include uncertainties involved in transitioning laboratory methods to field-use technology, and the ability to control the variabilities of sensor performance that result from site-specific conditions such as variations in soil stratigraphy, interference sources, presence of multiple contaminants, and changes in contaminant state.

ACCOMPLISHMENTS: Traditional methods of characterizing contaminant sites incorporate drilling, sampling, and off-site laboratory analysis, which are costly and time-consuming. It is estimated that costs for site investigations could be reduced by at least 50 percent for every contaminant for which a reliable in-situ chemical sensor is available. SCAPS has shown the capability to rapidly screen contaminated sites. SERDP continues to sponsor the accelerated development of additional sensors for SCAPS, including sensors to detect explosive compounds, solvents, and heavy metals.

In FY 1996, at the laboratory scale, an X-ray fluorescence (XRF) probe for metals detection was fabricated and tested, and a prototype coated-silver surface enhanced raman sensor (SERS) system was developed. Resonance enhancement in a fiber optic raman sensor (FORS) system produced a six-fold increase in signal for trichloroethylene (TCE). High-energy Nd:YAG (266nm) micro-lasers were incorporated into down-hole probes for Laser-Induced Breakdown Spectroscopy (LIBS) for metals detection and for advanced Laser-Induced Fluorescence (LIF) for BTEX. These both subsequently demonstrated improved sensitivity in the field compared to systems delivering the incident laser via the umbilical. As a near-term replacement for the original nitrogen laser, a XeCl excimer laser (308 nm) has been incorporated into all Navy SCAPS trucks for increased sensitivity to jet fuels. Successful field demonstrations of an electrochemical VOC sensor, a multiport sampler, and a VOC thermal desorption sampler were also conducted.

BENEFIT: SCAPS technology is expected to reduce the costs of traditional site screening by up to 90 percent, increase the number of data points by up to 400 percent, and significantly reduce the required time. Currently, there are over 300 DoD sites with leaking underground storage tanks which could be characterized using this technology, and that is only one of many potential cost-effective applications. This technology has been patented and licensed to commercial firms as well as being fielded by DoD and DOE. Rapid development and fielding of sensor technologies for SCAPS will significantly increase its return on investment.

FY 1997 Milestones		Planned Date
1.	Complete demos of improved sampler technologies	10/30/96
2.	Conduct third coordination meeting	10/30/96
3.	Complete initial description of analyte behavior in soil	12/31/96
4.	Complete valuation of quantitative aspects of SCAPS sampler technology	12/31/96
5.	Complete field tests of LIBS metal sensor	12/31/96
6.	Conduct demonstrations of XRF sensor	12/31/96
7.	Complete demonstration of improved TNT electrochemical sensor	01/31/97
8.	Complete field demonstration of resonance enhanced FORS probe	01/31/97
9.	Complete field tests of photofragmentation/LIF sensor	06/30/97
10.	Complete Final Program Report	10/31/97

PROJECT SUMMARY

PROJECT TITLE & ID: Surfactant-Enhanced Biodegradation of Contaminants; CU-731

RESEARCH CATEGORY: 6.1 Basic Research

LEAD AGENCY: U.S. Army

LAB: Waterways Experiment Station - Vicksburg, MS

PRINCIPAL INVESTIGATOR: Dr. Herbert L. Fredrickson

FY 1996 COMPLETED PROJECT

OBJECTIVE: The two objectives of this project were to determine the significance of soil sorption on bioavailability of representative organic pollutants in bioremediation systems, and to determine the applicability of biologically-derived surfactants for enhancing microbial destruction of contaminants, and associated cost advantages compared to synthetic surfactants.

BENEFIT: Reduction of the cost of land-farming and bioslurry reactor remediation operations for contaminants such as PCBs, PAHs, TNT, and chlorinated solvents.

ACCOMPLISHMENTS: Biotreatability studies of PAH-contaminated soils were conducted in FY 1996 to show that surfactants increase the water soluble concentration and microbial destruction of PAHs. Predictive models for desorption and microbial degradation were also developed. Both pure cultures and microbial consortia isolated from a PAH-contaminated site were shown to mineralize sorbed phenanthrene faster than desorption rates would predict.

TRANSITION: In FY 1997 this work will be continued by the Federal Integrated Biotreatment Program (project **CU-720**). A protocol to enhance microbial accessibility to contaminants will be developed.

PROJECT SUMMARY

PROJECT TITLE & ID: Air Sparging and In-situ Bioremediation Research and Demonstration at Picatinny Arsenal; CU-744

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: U.S. Army

LAB: U.S. Geological Survey - West Trenton, NJ

PRINCIPAL INVESTIGATOR: Mr. Jeffrey M. Fischer

FY 1996 COMPLETED PROJECT

OBJECTIVE: To develop methods for quantifying the total rate of removal of TCE contaminant from an air sparging remediation system, when enhanced by varying the sparge gas composition to include methane as a co-substrate for aerobic cometabolism.

BENEFIT: Design criteria resulting from this project could be used to determine the suitability of other sites for such sparging and enhanced biotreatment, which would reduce the cost and time required for cleanup.

ACCOMPLISHMENTS: In FY 1996, laboratory-microcosm and flow-through-column experiments with contaminated sediment were completed, which developed mathematical models for the transport of contaminants from the water table to extraction wells. These models are being scaled-up and evaluated, in ongoing, full-scale experiments on a well-characterized TCE plume at Picatinny Arsenal, to optimize the system.

TRANSITION: This technology will be considered as a treatment alternative in the Record of Decision (ROD) for future remediation of the site.

PROJECT SUMMARY

PROJECT TITLE & ID: Environmental Risk Assessment Program; CU-770

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: Environmental Protection Agency

LAB: Environmental Criteria & Assessment Office - Cincinnati, OH

PRINCIPAL INVESTIGATOR: Dr. Terry Harvey

FY 1997 FUNDS: $50K

OBJECTIVE: The goal of the Environmental Risk Assessment Program (ERAP) is the improvement of scientific methods and models for the performance and application of risk assessments for human and ecological issues. As such, the program involves joint scientific reviews, with consensus deliberations, of pollutants of mutual concern to DoD, DOE and EPA, and the development of new and improved human health, exposure and ecological methodologies for assessing risks related to federal facilities. The program strives to identify and evaluate existing risk assessment processes, data gaps and weaknesses in current methodologies; to explore, develop and validate alternative risk and exposure assessment methods and models for application at DoD and DOE facilities; and to share new risk assessment methods and models across federal agencies and the scientific community.

TECHNICAL APPROACH AND RISKS: The program utilizes personnel and resources from DoD, DOE, and EPA who work jointly on three different Working Groups under the direction of the Advisory and Coordinating Committee (ACC). The Material/Chemical Risk Assessment (MCRA) Working Group is currently chartered to prioritize the chemicals of mutual concern and then to derive consensus toxicity values for the highest priority chemicals of concern. The Human Risk Assessment Methodology (HRAM) Working Group is chartered to evaluate current human health and exposure methodologies for ways to improve them or to propose alternate methodologies for validation and use when appropriate. The Ecological Risk Assessment Methodology (ERAM) Working Group is chartered to evaluate current risk assessment methodologies or to propose alternate methodologies for validation and use when appropriate.

ACCOMPLISHMENT: Potential for greatly reduced remediation costs. Acute, subacute, subchronic, chronic, toxicokinetic, reproductive, and developmental studies conducted by the U.S. Army and the U.S. EPA provided the scientific database to develop a 600-fold higher RfD of 3E-2 mg/kg/day for TNB based on toxic effects (hematopoietic effects) common to other nitroaromatics. The new RfD has undergone external peer review and is in final adoption stage by the inter-agency Advisory and Coordinating Committee.

BENEFIT: The program will provide consensus toxicity values for assessing human health and ecological risks(s) pertaining to materials and chemicals found at federal facilities. The program will also make available the most appropriate scientifically based methodologies for consistent application to these risk assessments.

FY 1997 Milestones	Planned Date
1. MCRA Working Group's discussion of the peer review comments for TNB and TNT and finalization of the assessment in preparation for sending to the ACC	08/26/96
2. MCRA Working Group verification of 10 Warfare Agent chemicals; finalized for submission to COT for peer review	09/23/96
3. MCRA Working Group to consider 8 draft chemical assessments	09/23/96
4. MCRA Working Group - Edit of TNB and TNT assessment prior to release to the ACC	09/30/96
5. HRAM Working Group's review of VX, MCRA Report for scaling factor	11/30/96
6. MCRA Working Group's contractual support to modify last 8 chemical profiles	01/31/97
7. HRAM Working Group's draft report on military specific exposure criteria	01/31/97
8. ERAM Working Group's discussion of the ecological exposure model and solicitation of comments. Discussion and evaluation of the ecological risk assessment methodologies	02/11/97
9. MCRA Working Group's edit of 10 Warfare Agent chemicals prior to release to the ACC	02/15/97
10. HRAM Working Group's Preliminary Acute/Chronic Correlation for Risk Assessment Report	03/31/97
11. Final Report of Impact/Cost - Federal Savings per TNB/TNT	05/15/97
12. HRAM Working Group's final report on military specific exposure criteria	05/01/97
13. HRAM Working Group's final report on Acute/Chronic Correlation for Risk Assessment Report	07/31/97
14. Final submission of all written materials to SERDP management	09/30/97

PROJECT SUMMARY

PROJECT TITLE & ID: National Environmental Technology Test Site (NETTS) Program — McClellan AFB; CU-861

RESEARCH CATEGORY: 6.4 Demonstration and Validation

LEAD AGENCY: U.S. Air Force

LAB: McClellan Air Force Base - Sacramento, CA

PRINCIPAL INVESTIGATOR: Mr. Kevin Wong

FY 1997 FUNDS: $130K

OBJECTIVE: The NETTS goal is to enable efficient demonstration of candidate detection, monitoring or cleanup technologies, either on an individual basis or in parallel with similar projects, under representative hydrological and climate regimes as found at many contaminated sites in the DoD. Current environmental cleanup technologies are costly, slow, and largely ineffective. The program will provide test beds for research to fully understand the mechanisms in proposed treatment processes. The NETTS National Test Location at McClellan AFB provides test sites to investigate technologies for treatment of unsaturated soils and extracted soil-gas contaminated with chlorinated solvents, as well as ex-situ treatment of contaminated groundwater. As part of its cleanup effort, McClellan AFB (MAFB) has been well characterized.

TECHNICAL APPROACH AND RISKS: As a NETTS test location, MAFB provides a well-characterized demonstration site for applied research, demonstration, and evaluation of promising cleanup and monitoring technologies. MAFB currently has four operational and two planned Soil Vapor Extraction (SVE) Systems. All systems have dedicated utilities, adjacent to it allowing for convenient slip-stream demonstrations. The first of the two planned systems is scheduled to be operational in December 1996. McClellan AFB's groundwater treatment plant currently services 23 extraction wells. The SVE systems and ground water treatment facility provide opportunities for demonstrating in-situ and ex-situ techniques for remediating soils and groundwater contaminated with solvents. There are over 375 groundwater monitoring wells located on and around McClellan AFB.

ACCOMPLISHMENTS: The McClellan NETTS test location achieved the milestones planned in the FY 1996 SERDP Execution Plan on schedule and within budget including completion and maintenance of site infrastructure and completion and distribution of the protype of the Cost and Performance Database.

BENEFIT: Test locations will be fully characterized and monitored areas where new technologies can be quickly and effectively demonstrated. This will save time and money for

technology demonstrations by providing on-site management, pre-characterization, and more timely permitting. An established, dedicated test site will enable technology demonstrations to be performed at a cost lower than that of a one-time demonstration elsewhere.

FY 1997 Milestones		Planned Date
1.	In-situ Cometabolic Biotreatment of Cl-solvents (DERA/Oregon State University)	Ongoing FY 1997
2.	Flameless Thermal Oxidation (DERA/private)	Completed FY 1996
3.	Elastomeric Polymer Filter (DERA/private)	Completed FY 1996
4.	Vadose Zone Sensor (DERA/private)	Completed FY 1996
5.	Dual Phase Treatability (DERA/private)	Completed FY 1996
6.	Photolytic (DERA/private)	Completed FY 1996
7.	Silent Discharge Non-thermal Plasma (DERA/private)	Completed FY 1996
8.	Photocatalytic TiO_2 (CU-131)	Ongoing FY 1997
9.	Biofilter (SERDP)	Ongoing FY 1996
10.	Gore Sorber (soil gas survey)	Planned FY 1997
11.	Acoustically Enhanced Remediation (DOE/private)	Planned FY 1997
12.	In-situ Bioremediation of Sediments (DOE/private)	Planned FY 1997
13.	SVE Offgas Treatment (private)	Planned FY 1997
14.	Non-TiO_2 Photocatalytic Destruction (private)	Planned FY 1997
15.	Interim Report	12/01/97

PROJECT SUMMARY

PROJECT TITLE & ID: National Environmental Technology Test Sites (NETTS) Program — Naval Construction Battalion Center (CBC), Port Hueneme, CA; CU-863

RESEARCH CATEGORY: 6.3 Advanced Development

LEAD AGENCY: U.S. Navy

LAB: Naval Facilities Engineering Service Center - Port Hueneme, CA

PRINCIPAL INVESTIGATOR: Mr. Ernest Lory

FY 1997 FUNDS: $600K

OBJECTIVE: The objective of Navy Construction Battalion Center (CBC) NETTS National Test Location (NTL) at Port Hueneme, CA is to support demonstration of systems for characterizing and remediating soil, sediments, and groundwater contaminated with fuel hydrocarbons and/or waste oil. It provides test sites to investigate both ex-situ technologies for treatment of soils and in-situ technologies for groundwater contaminated with fuel hydrocarbons.

TECHNICAL APPROACH AND RISKS: The Test Location Manager (TLM) at CBC, Port Hueneme will provide programmatic, infrastructure and technical support to NETTS for fuel hydrocarbon and waste oil characterization and remediation demonstrations. This support will include integration of the following: (1) QA/QC procedures, (2) test protocol guidance, (3) demonstration reporting format, and (4) environmental setting, cost-and-performance data retrieval guidance. Infrastructure and its management (operation and maintenance) will include: (1) monitoring wells, (2) in-line sensor network, (3) ex-situ treatment facility with hazardous material handling capability, (4) utilities, (5) contaminated soil, sediments and ground water resources. Technical support will include: (1) characterizing and monitoring contaminants, (2) processing permits, (3) supporting stakeholder involvement, and (4) transferring technologies.

ACCOMPLISHMENTS: The Port Hueneme NETTS test location provided: (1) management support for SERDP projects including installation of utility service, (2) support for the Oxnard Plain Military Community Public relations process, (3) operation and maintenance of ex- and in-situ demonstration sites, (4) completion of draft revision of the D/NETDP brochure, (5) completion of draft review of draft revision of the D/NETDP Guidelines for Quality Technology Demonstrations, (6) guidance to four PIs on preparing Application Analysis Report following instructions found in the Guidelines for Quality Technology Demonstrations.

BENEFIT: The NTL for fuel hydrocarbon and waste oil provides the following: (1) well characterized test locations, (2) controlled field conditions for comparative evaluations of technologies, (3) uniform evaluation criteria for demonstrations, reporting of results and technology transfer, and (4) cost savings through amortization of infrastructure and management.

	Demonstration	Status
1.	SCAPS (LIF at diesel spill) (CU-729)	Completed FY 1996
2.	Ex-situ Static Pile Bioremediation Phase II (CU-020)	Completed FY 1996
3.	Hot Air Vacuum Extraction (CU-020)	Completed FY 1996
4.	Biocell #1 — Fuels (CU-720)	Completed FY 1996
5.	Portable Vapor Detection System (private)	Completed FY 1996
6.	Agent 313 Solvation Chemistry (RCI/private)	Completed FY 1996
7.	In-situ Bioremediation of Fuel (Groundwater Recirculation Wells) (CU-030)	Ongoing FY 1997
8.	Bioremediation Efficiency Monitoring (CU-030)	Ongoing FY 1997
9.	Aerobic Biodegradation of a Contaminated Aquifer (Air Sparging) (CU-095)	Ongoing FY 1997
10.	Risk-Based Corrective Action (RBCA) Survey (NAVFAC)	Ongoing FY 1997
11.	Subsurface Gas Flowmeter (CU-404)	Planned FY 1997
12.	Phytoremediation (ONR)	Planned FY 1997
13.	On-line Remote Monitoring of Static Biopiles (NFESC)	Planned FY 1997
14.	Tidal-Driven Passive Bioventing (ESTCP)	Planned FY 1997
15.	Characterization/Monitoring Technologies for RBCA (NAVFAC)	Planned FY 1997
16.	Enhanced Degradation of Diesel by Amended Humic Acid (ONR)	Planned FY 1997

	FY 1997 Milestones	Planned Date
1.	Remove Pile #2	02/01/97
2.	Conduct NEX plume monitoring	02/01/97
3.	Review RCI Project Report	02/01/97
4.	Support DOE CU-404 field tests	02/01/97
5.	Support CU-095 tracer study	03/01/97
6.	Conduct NEX plume monitoring	07/01/97
7.	Support dismantling CU-095 air sparging unit	09/30/97

PROJECT SUMMARY

PROJECT TITLE & ID: National Environmental Technology Test Sites (NETTS) Program — Wurtsmith AFB; CU-864

RESEARCH CATEGORY: 6.3 Advanced Development

LEAD AGENCY: Environmental Protection Agency

LAB: University of Michigan, National Center for Integrated Bioremediation Research and Development - Oscoda, MI

PRINCIPAL INVESTIGATOR: Dr. Michael Barcelona

FY 1997 FUNDS: $800K

OBJECTIVE: To operate and maintain a NETTS National Test Location at the National Center for Integrated Bioremediation Research and Development (NCIBRD) which investigates advanced technologies in site characterization, decontamination of hazardous wastes, and remediation of spill and disposal sites. Under NETTS, well-characterized test sites will be provided for technologies with evident promise for complete and cost-effective remediation with minimal environmental disruption, which are favored for facility usage. These technologies involve on-site and in-situ processes which integrate biological and physicochemical methods for treatment of soils and groundwater contaminated with fuels, chlorinated solvents, and organic mixtures. NCIBRD is located at the recently decommissioned Wurtsmith Air Force Base in Oscoda, Michigan, which has numerous fuel and chlorinated solvent contamination sites resulting former Air Force activities.

TECHNICAL APPROACH AND RISKS: Activities at NCIBRD include an array of research, development, demonstration, testing and evaluation efforts toward the transfer of field and laboratory findings into successful remediation practice. The program focuses on several specific problems relating to the development of core biotechnologies such as the enhanced understanding of microbiology and microbial geochemistry, improved means for implementing biotechnology in engineering applications, and accelerated bioremediation of contaminated soils and groundwater. Controlled programs on site characterization and in-situ integrated remediation technologies for decontamination of hazardous substances in wastes, soils, and ground water are conducted at the facility. The majority of the sites at the base have been characterized to some extent. Several of the larger sites are under hydraulic control by way of pump-and-treat systems. A subset of three fuel and chlorinated solvent sites have been characterized geochemically and microbially in support of in-situ bioremediation. The facilities provide a focal point for coordination and cooperation within the broad community of institutions, agencies, and corporations currently attempting to develop these technologies.

ACCOMPLISHMENTS: The Wurtsmith NETTS test location successfully provided the capability to investigate advanced technologies in site characterization, decontamination of hazardous wastes, and remediation of spill and disposal sites. In FY 1996, the NCIBRD successfully completed three demonstrations and provided field support for five R&D projects.

BENEFIT: This test location provides significant direct and indirect benefit to the DoD, DOE, and EPA environmental R&D programs by enabling advanced site characterization and remediation technologies to be evaluated on a common baseline. It also provides a standardized testing procedures and cost-and-performance evaluation guidelines which should expedite the approval process for new technologies and in turn facilitate the transfer of those technologies from the development stage to operational use. Field-scale testing at sites which are well characterized and monitored on a continuing basis will save considerable amounts of money in evaluating individual technologies for DoD use.

	Demonstration	**Status**
1.	Intrinsic Bioremediation (CU-405)	Completed FY 1996
2.	Subsurface Bioremediation Process Monitoring Indicators (CU-383)	Completed FY 1996
3.	Genetic Diversity Monitoring in Plants and Wildlife (CS-246) Phase I	Completed FY 1996
4.	Natural Attenuation Data Consolidation (SERDP/EPA)	Planned FY 1997
5.	Genetic Diversity Monitoring in Plants and Wildlife (CS-246) Phase II	Planned FY 1997
6.	Development of Simulators for In-situ Remediation, Evaluation, Design, and Operation (CU-1062)	Planned FY 1997
7.	Aerobic Degradation of TCE by Facultative Microorganism (DOE)	Planned FY 1997
8.	Ex-situ Biofilter for TCE-contaminated Groundwater (AF/USACE)	Planned FY 1997
9.	In-situ Bioremediation and Natural Attenuation (private)	Planned FY 1997
	R&D Projects	**Status**
1.	Monitoring and Predicting In-situ Bioremediation Great Lakes/mid-Atlantic Regional HSRC (CU-405)	Completed FY 1996
2.	In-situ Measurement of Microbial Metabolic Activity Western Regional HSRC (CU-405)	Completed FY 1996
3.	Enhancing (in-field) Bioavailability of Complex PAH Mixtures North-eastern Regional HSRC (CU-405)	Completed FY 1996
4.	Quantifying Solvent Degradation during Bioventing of Fuels South/Southwest Regional HSRC (CU-405)	Completed FY 1996
5.	Use of Organic Acids to Enhance DNAPL Bioremediation Great Plains/Rocky Mountain Regional HSRC (CU-405)	Completed FY 1996

PROJECT SUMMARY

PROJECT TITLE & ID: National Environmental Technology Test Sites (NETTS) Program — Dover AFB; CU-866

RESEARCH CATEGORY: 6.3 Advanced Development

LEAD AGENCY: U.S. Air Force

LAB: Armstrong Laboratory - Tyndall Air Force Base, FL

PRINCIPAL INVESTIGATOR: Ms. Alison Thomas

FY 1997 FUNDS: $800K

OBJECTIVE: This NETTS National Test Location, which is managed by the Environics Directorate of the Armstrong Laboratory, provides test sites for the application of characterization and remediation technologies to soil and water contaminated by chlorinated solvents. Its centerpiece is the Groundwater Remediation Field Laboratory (GRFL). The GRFL consists of isolated, well-monitored, in-situ controlled release test cells, in which mass-balance studies of the fate, transport and remediation of DNAPLs may be performed, weather protection, office space and a small analytical laboratory.

TECHNICAL APPROACH AND RISKS: Operations consist of long-term monitoring of the site, as well as project support to include injection of the constituent (TCE primarily), demonstration of innovative technologies, and disposal of a minimal amount of waste from the tests. The GRFL program consists of construction of a maximum of five test cells spaced approximately 50 feet apart and constructed and operated in a way to minimize the potential for environmental contamination. Basic design consists of interconnected, steel barrier piling sections (2 feet width) forming a rectangular pattern (test cells will range in size up to 1800 square feet). By driving the sheet piling 3-5 feet into the clay aquitard (approximately 30 - 40 feet from the surface), a coffer is formed which prevents vertical and lateral migration outside the confines of the box. There is an additional secondary containment coffer surrounding the primary coffer, which is similarly sealed at the bottom and at each joint. The annulus between the cells is filled with water to produce an inward hydraulic gradient. The annulus and inner cell are continuously monitored for leakage. There are both upgradient and downgradient monitoring wells outside the secondary coffer. Other sheet pile designs to be considered include geomembrane and grout type barriers. Risks are minimal for the program as designed and can be controlled. Primary risk is that introduced material will escape and contaminate an aquifer. Vertical migration is retarded very well by a twenty foot thick underlying clay layer with a hydraulic conductivity four orders of magnitude less than the overlying strata. Double sheet piling, grouting, monitoring, developing emergency pump-and-treat system, and distance to the nearest potential users of the aquifer virtually eliminate the risk from lateral migration. A worst-case risk analysis has

shown that risk of significant aquifer and surface water contamination and human health impact is negligible even if no barriers are emplaced, cleanup is not attempted, and the TCE source ar. The process for obtaining permits for contained releases has been worked out and it is expected to take less than 90 days per permit application.

ACCOMPLISHMENTS: The Dover NETTS test location successfully provided the capability for application of characterization and remediation technologies to soil and water contaminated by chlorinated solvents. In FY 1996, the Dover location continued development of the GRFL program.

BENEFIT: The GRFL is a unique resource, the primary purpose of which is to provide contained release cells for DNAPL research and development that avoid making the gross assumptions that would be necessary if experiments were conducted in previously contaminated aquifers. DNAPLs are immiscible with and denser than water, and when spilled on the ground, migrate below the water table. Once below the water table, they are difficult to locate and remove. Currently there are no acceptable methods for removing or treating DNAPLs. These technologies must be developed to protect the public from the potential health risks associated with DNAPLs in drinking water.

Demonstration	Status
1. SCAPS VOC sensors (Electrochemical and FORS) (CU-729)	Completed FY 1996
2. Natural Attenuation (USGS)	Completed FY 1996
3. Cooxidation of TCE during Bioventing of JP-4 (AATDF)	Ongoing FY 1997
4. Aquifer Restoration by Enhanced Source Removal (CU-368)	Ongoing FY 1997
5. Resistive Heating (AF)	Ongoing FY 1997
6. Cometabolic Bioventing of Chlorinated Solvents (RTDF/AF)	Ongoing FY 1997
7. Intrinsic Bioremediation (RTDF)	Ongoing FY 1997
8. Pulsed Pumping (University of Waterloo)	Ongoing FY 1997
9. Permeable Reactive Barriers for In-situ Treatment of Chlorinated Solvents (CU-107)	Planned FY 1997
10. Bioenhanced In-well Vapor Stripping to Treat TCE (CU-1064)	Planned FY 1997
11. Steerable Cone Penetrometer (DOE)	Planned FY 1997
12. Combination of Lasagna Tech/Jet Grouting/Iron Barriers (RTDF)	Planned FY 1997
13. Low Permeability Barriers/Jet Grouting (DOE/private)	Planned FY 1997
14. Innovative Monitoring Technology (RCI)	Planned FY 1997

PROJECT SUMMARY

PROJECT TITLE & ID: Bioremediation of Energetic Materials; CU-886

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: U.S. Air Force

LAB: Armstrong Laboratory - Tyndall Air Force Base, FL

PRINCIPAL INVESTIGATOR: Ms. Alison Thomas

FY 1997 FUNDS: $150K

OBJECTIVE: A wide variety of sites in the U.S. and Europe are extensively contaminated with Dinitrotoluene (DNT). Nitroaromatic contamination can be attributed to past production and demilitarization activities. Most of the subsequent wastewater and washout was discharged to unlined lagoons, resulting in soil and groundwater contamination. The DoD has identified more than 1,200 explosive contaminated sites. The objective is to provide a bioremediation technique to degrade DNT-contaminated groundwater and soils. In accordance with the DoD's Project Reliance, the Air Force's nitroaromatic research will transition to the US Army.

TECHNICAL APPROACH AND RISKS: Scientists at the Armstrong Laboratory (AL/EQ) have isolated several microbes that utilize 2,4-DNT as a growth substrate. The microbes have the ability to completely degrade the nitroaromatic compound to innocuous compounds (i.e., carbon dioxide and water). During FY 1996, AL/EQ researchers were able to isolate microbes that degrade 2,6-DNT, previously found to be inhibiting the DNT degradation. Bench-scale bioreactor studies are being conducted to determine degradation rates, nutrient and oxygen requirements and further refine the remediation process for the upcoming field study. Concurrently, a method for anaerobic degradation of the mixtures is being studied that will eventually augment the DNT bioremediation technique. The field work for FY 1997 will be performed at the Volunteer Army Ammunition Plant (VAAP) National Test Site. The purpose of this field demo is to determine the performance and costs for utilizing a fluid bed reactor to degrade DNT contaminated groundwater.

ACCOMPLISHMENTS: Bacteria that consume 2,6-DNT during growth were isolated in FY 1996, which have enabled the development of an effective bioremediation process for treatment of DNT-contaminated material. Bench-scale bioreactor studies are continuing to determine degradation rates, nutrient and oxygen requirements. An anaerobic degradation technique is also being studied concurrently.

BENEFIT: This project will develop a destructive bioremediation process for nitroaromatic compounds, specifically DNT. The process will complement the U.S. Army's nitroaromatic

remediation "tool box," which is tailored to site specific needs. The knowledge gained will facilitate the aerobic degradation of the other more troublesome nitroaromatic compounds like trinitrotoluene (TNT).

FY 1997 Milestones	Planned Date
1. Conduct anaerobic inhibition studies	08/31/96
2. Initiate lab reactor studies	09/01/96
3. Complete lab reactor studies	11/01/96
4. Site preparation	12/01/96
5. Begin field demonstration	01/01/97
6. Complete field demonstration	09/01/97
7. Publish final report	12/01/97

PROJECT SUMMARY

PROJECT TITLE & ID: Natural Attenuation of Explosives Contaminants; CU-1043

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: U.S. Army

LAB: Waterways Experiment Station - Vicksburg, MS

PRINCIPAL INVESTIGATOR: Dr. Judith C. Pennington

FY 1997 FUNDS: $850K

OBJECTIVE: Natural attenuation may be an attractive alternative to more expensive remediation technologies at sites that meet well-defined selection criteria, acceptable risk levels, and that satisfy specific regulatory concerns. However, a significant unanswered question associated with natural attenuation is what processes are relevant and require monitoring to assure that attenuation is effective. Application of existing biomarker and stable isotope technology to in-situ monitoring for natural attenuation of explosives holds the greatest promise for addressing this question. Specific objectives of this project are to (a) identify partner(s) for investigating potential biomarkers, (b) initiate development of mesocosms, and (c) develop an approach for the application of stable isotopes to natural attenuation monitoring.

TECHNICAL APPROACH AND RISKS: Emphasis will be placed on identifying effective biomarkers, such as microbial deoxyribonucleic acid (DNA) and/or lipid signatures, and stable- isotope techniques that indicate degradation of explosives. State-of-the-art capabilities for these technologies exist at several universities and are under development at WES. Therefore, identification of a university partner and development of mesocosms at WES will be critical first tasks. The third task will be formulation of a specific approach for this project which effectively integrates the project into an existing demonstration project on natural attenuation funded by the Environmental Security Technology Certification Program (ESTCP).

ACCOMPLISHMENTS: Field soil sampling was conducted in FY 1996 to test initial sampling SOPs and to provide samples for ongoing analysis. Emphasis was placed on techniques involving microbial DNA determinations, lipid signatures, and stable isotope ratio measurement that indicate degradation of explosives. Initial results indicated that these techniques had potential application in screening and monitoring.

BENEFIT: Development of effective biomarkers for monitoring natural attenuation will permit application of this technology to sites meeting appropriate selection criteria. Cost of pump-and-treat remediation is approximately $300 per ton, while natural attenuation cost is

estimated to be $30 per ton. In addition to the significant cost-saving potential, this project will provide support for and become an integral part of an ESTCP-funded effort for demonstrating natural attenuation of explosives.

FY 1997 Milestones	Planned Date
1. Characterize field samples with gene probing (WES)	12/30/96
2. Update conceptual model based on new grid site CPT/HPT data (WES)	12/30/96
3. Provide preliminary rate parameters and site capacity data for field soils (WES)	03/30/97
4. Complete radiorespirometry analyses on lipid fractions from field samples (WES)	03/30/97
5. Evaluate and refine SOPs for field sampling (WES)	03/30/97
6. Conduct two day Tri-Services workshop on monitoring tools for natural attenuation of explosives (WES)	04/15/97
7. Field test modified SOPs and complete second field sampling (WES)	06/30/97
8. Provide final rate parameters and site capacity data for field soils (WES) (Moved to FY 1998 due to budget reductions)	06/30/97
9. Validate microbial lipid assays for community structure with direct field samples (WES) (Moved to FY 1998 due to budget reductions)	09/30/97
10. Initiate application of microbial lipid and DNA biomarker techniques to seconds field samples (WES)	09/30/97
11. Conduct mesocosm incubations with time-series isotope tests (CRREL)	09/30/97
12. Interim Report	11/30/97

PROJECT SUMMARY

PROJECT TITLE & ID: Application of Neural Networks Coupled with Genetic Algorithms to Optimize Soil Cleanup Operations in Cold Climates; CU-1049

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: U.S. Army

LAB: Cold Regions Research and Engineering Laboratory - Hanover, NH

PRINCIPAL INVESTIGATOR: Dr. John M. Sullivan

FY 1997 FUNDS: $215K

OBJECTIVE: This project has two objectives for site characterization and contaminant fate, transport, and remediation analysis for site cleanup alternatives. The first objective is the automatic decomposition of Ground Penetrating Radar (GPR) signals into stratigraphic layers using Neural Networks. GPR can probe the subsurface non-invasively at high resolutions. However, methods for quantitative interpretation of these data are sparse. We propose to train Neural Networks, which are ideally suited for pattern recognition, to recognize various stratigraphic layer configurations. With this tool in place, enhanced quantitative site conceptualizations become available. The second objective is the development and implementation of a rapid solution strategy for analyzing selected remediation/monitoring alternatives using Neural Networks coupled to Genetic Optimization routines. The Neural Networks will be trained to recognize a contaminant distribution as a function of the boundary conditions. The Genetic Optimization routines will be developed for decision analysis of various remediation alternatives and monitoring strategies based on the simulated behavior predicted by the Neural Network. The coupling of these applied research areas can potentially yield an analysis technique that holds the promise of illuminating the subsurface stratigraphy and the deployment of an optimum remediation strategy.

TECHNICAL APPROACH AND RISKS: Neural Network Models will be trained to decompose GPR signals into stratigraphic layers such as top-of-permafrost, bottom-of-permafrost, water table, and top-of-bedrock. Extensive GPR and ground-truth borehole data collected on several sites at Fort Wainwright, AK, and elsewhere will be used for training the Neural Network, m the traditional governing equations for electromagnetic wave propagation. This approach has been successfully applied by the investigators to non-destructive acoustic-wave analysis of composite materials. Electromagnetic wave propagation in natural soils is a much more complex problem, for which these techniques are as yet untested. If successful, this modeling strategy can be extended for non-invasive evaluation of the subsurface in general, including such stratigraphic features as boundaries between sand, silt and clay. Using the same test sites at Ft. Wainwright, AK, a Neural Network system coupled with a genetic optimization algorithm will be employed to assist in

the decision analysis of alternative remediation treatments and of various configurations within a remediation treatment.

ACCOMPLISHMENTS: GPR signal propagation in soils has been simulated numerically (in 3-D) and the numerical formulations for wave propagation have been successfully compared with GPR field data.

BENEFIT: The expected benefits of this project are an accurate, non-invasive tool for site conceptualization and an optimized remediation and monitoring deployment plan for sites where cleanup and monitoring of groundwater is required. The ability to characterize a site will increase by two orders of magnitude from current practices. The gains realized in predicting subsurface contaminant flow would be an order of magnitude. The optimized deployment routines could reduce the remediation and monitoring cost of a contaminated site by one third. The potential opportunity to transfer this technology to many contaminated sites (not just cold regions) is excellent.

FY 1997 Milestones		Planned Date
1.	Formulate Neural Network Model Architecture and training methodology	11/01/96
2.	Test/Train Neural Network Model using GPR data correlated with ground-truthing core samples	01/01/97
3.	Validate Neural Network Model using GPR data correlated with ground-truthing core samples	03/01/97
4.	Formulate genetic optimization algorithms for remediation strategies	04/01/97
5.	Train Neural Network Model to predict based on boundary conditions groundwater flow	06/01/97
6.	Submit interim report on stratigraphy predictions using the Neural Network Model	09/01/97

PROJECT SUMMARY

PROJECT TITLE & ID: Multisensor Data Fusion for Detection of Unexploded Ordnance; CU-1052

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: U.S. Army

LAB: Waterways Experiment Station - Vicksburg, MS

PRINCIPAL INVESTIGATOR: Dr. Ernesto Cespedes

FY 1997 FUNDS: $375K

OBJECTIVE: The first objective of this project is to develop a better understanding of the environmental factors and phenomenologies that dictate success and failure in subsurface anomaly detection through a careful study of controlled field tests involving several sensor technologies. The primary source of field data will be the U.S. Army Environmental Center and the contractors who participated in the Jefferson Proving Ground (JPG), IN, Phase I, Unexploded Ordnance (UXO) Advanced Technology Demonstrations. The second objective is to identify the most promising data analysis, or data fusion, approach to improve UXO detection and to demonstrate detection improvement through the fusion of multiple data sets from the previously mentioned field tests.

TECHNICAL APPROACH AND RISKS: Two distinct elements are being proposed:

a. Phenomenology Studies. While the JPG UXO technology demonstrations provided an unbiased ranking of current technology performance in the field, it did not provide a mechanism for a scientific evaluation of why particular systems did or did not perform well. The first element of this project would be to support such an evaluation. This would be accomplished by forming an honest-broker technical review committee made up of government scientists who would solicit genuine technical evaluations of their system's performance from several of the participants of the Technology Demonstrations. The review committee would critique each of these self-examinations and prepare a report that would address many of the phenomenological issues that affect sensor performance in this environment and provide general guidance for system improvements that would feed the effort to develop a multisensor detection platform. Care will be taken not to infringe on the proprietary rights of the technology demonstrations participants.

b. Data Fusion Algorithm(s). The second element of this project will focus on the combination of data from several sensors to optimize detection system performance. This effort would begin by examining more closely any attempts at data fusion performed by JPG demonstration participants who utilized multiple sensors. A prototype data fusion algorithm

would then be developed that would be tested on JPG data taken from both multiple sensor platforms and from multiple sensors used by different participants that could be spatially coregistered. The final product of this effort would be a model that could easily be adapted to the fusion of data from the array of sensors that would serve as the prototype UXO detection system.

The greatest technical risk lies with acquiring data of sufficient quantity and quality to accomplish the stated objectives. In concert with the concerns of data quality is the issue of being able to acquire physics-based models for predicting sensod sophistication to deal with the phenomenologies that govern target/sensor/background interactions.

ACCOMPLISHMENTS: This FY 1996 new start project is evaluating Surface-applied methods such as magnetics, electromagnetic induction, and ground penetrating radar as well as airborne-deployed methods, and Geographic Information Systems (GIS) data management tools.

BENEFIT: The successful conduct of the elements of this research project will place the U.S. Army Corps of Engineers in a position to assemble a prototype multisensor UXO detection platform along with the software necessary to accomplish fusion of the enormous amount of data such a platform will develop. Follow-on commercialization of this platform will provide a tremendous financial savings over current man-in-the-loop UXO detection and clearance operations that focus on areas that are very limited in physical size.

FY 1997 Milestones	Planned Date
1. Acquire JPG Tech Demo participant data sets and/or solicit partipants' self-evaluations	12/31/96
2. Complete examination of existing JPG data fusion algorithms	12/31/96
3. Complete evaluations of JPG data sets against ground truth	06/30/97
4. Complete design and testing of multisensor data fusion algorithm using JPG data	06/30/97
5. Complete TOC review of phenomenology, evaluations and fusion exercises	09/30/97
6. Complete an enhanced prototype multisensor platform data fusion procedure	09/30/97
7. Complete final report and make recommendations to SERDP	12/31/97

PROJECT SUMMARY

PROJECT TITLE & ID: Development of Simulators for In-Situ Remediation Evaluation, Design, and Operation; CU-1062

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: U.S. Army

LAB: Waterways Experiment Station - Vicksburg, MS

PRINCIPAL INVESTIGATOR: Dr. Mark Dortch

FY 1997 FUNDS: $550K

OBJECTIVE: The ultimate goal in remediation modeling is to minimize remediation costs and environmental and human risks while maximizing cleanup. Toward this end, the general goals of this project are: (1) to develop reliable simulators for promising technologies of interest to DoD, DOE, and the regulatory community, and (2) to provide efficient access to multiple remediation simulators through a common user environment amenable to multi-disciplinary cleanup teams. A common, graphical user environment has been developed for these simulators; it is the DoD Groundwater Modeling System (GMS). The GMS provides conceptualization, parameterization, visualization, and animation capabilities. Additionally, GMS extensions, either ongoing or planned, will provide capabilities for conducting remediation, uncertainty, optimization, and cost analyses. The primary technical objectives of this project are to: (1) Develop/enhance state-of-the-art remediation simulators for the following technologies: in-situ bioremediation; surfactant-enhanced bioremediation; electrokinetic-enhanced bioremediation (EK-bio); electrokinetic-enhanced mobilization of metals (EK); natural attenuation of petroleum hydrocarbons (NA); natural attenuation of explosives (NAX); in-situ chemical treatment (ISCT); surfactant/cosolvent flushing to recover NAPLs; soil vapor extraction (SVE) and bioventing (BV); and air sparging (AS); and (2) Verify these simulators against available laboratory and field data; and (c) incorporate these simulators into the GMS to provide DoD, DOE, and other users with the computational ability to assess the tradeoff between environmental risk (cleanup level) and cost-effectiveness for a variety of cleanup technologies prior to their implementation.

TECHNICAL APPROACH AND RISKS: Remediation simulator development will proceed along three paths, in order of priority: (1) utilize existing, proven remediation simulators where available and consistent with project goals, (2) modify promising groundwater codes to simulate additional technologies as appropriate, or (3) develop new codes as required for efficient simulation of innovative technologies. All simulators will be verified against available laboratory and field data. Where data permit, the simulators will be applied for NETTS Test Sites. Results of these evaluations and the simulator codes will be documentation. Each simulator will be implemented in the GMS. This project strongly

leverages technical partnering and collaboration with ongoing and proposed basic and applied research in subsurface flow, contaminant fate/transport, remedial methods, remediation simulation under heterogeneous subsurface conditions, GMS-user environment development, and high performance computing in environmental quality modeling. Technical risk issues involve: (1) uncertainty regarding key processes in complex remediation technologies; (2) the scarcity of experimental or field data for innovative technologies; and (3) the general adequacy of differing computational resources on which to run complex models efficiently. Leveraging against new CHSSI (Common High-Performance Scalable Software Initiative) and Army High-Performance Computing (AHPC) efforts will address several of the high-performance computing issues associated with simulator development and execution.

BENEFIT: The GMS-based simulators will permit efficient evaluation of multiple remediation technologies for site-specific conditions, allowing selection of effective and cheaper cleanup actions. Such simulators are needed to support advocacy for biogeochemically complex alternatives that are faster, more effective, and/or more cost-efficient than traditional methods. Simulators will improve the remedial design by permitting cleanup specialists to consider multiple scenarios that could increase cleanup effectiveness.

FY 1997 Milestones	Planned Date
1. Develop approach for integrating isotope and biomarker data into NAX simulator (WES)	12/31/96
2. Develop plans for SEAM3D NETTS verification (WES)	03/31/97
3. Present NAX simulator at Tri-Services NAX workshop (WES)	04/15/97
4. Develop detailed plan for ISCT development and initiate (PNL)	05/31/97
5. Develop plans for NA simulator testing at NATS (AL/EQ and WES)	07/31/97
6. Complete addition of boundary condition options to UTCHEM (contractor)	09/30/97
7. Select cosolvent simulator and test site (WES)	12/31/97
8. Interim Report	12/31/97

PROJECT SUMMARY

PROJECT TITLE & ID: Bioenhanced In-well Vapor Stripping to Treat Trichloroethylene; CU-1064

RESEARCH CATEGORY: 6.3 Advanced Development

LEAD AGENCY: U.S. Air Force

LAB: Armstrong Laboratory - Tyndall Air Force Base, FL

PRINCIPAL INVESTIGATOR: Dr. Mark N. Goltz

FY 1997 FUNDS: $280K

OBJECTIVE: The objective of this project is to demonstrate the potential of combining two innovative, recently demonstrated, remediation technologies, in-well vapor stripping and in-situ aerobic cometabolic bioremediation, to cleanup an area contaminated with separate phase (DNAPL) and dissolved phase TCE.

TECHNICAL APPROACH AND RISKS: Under this project, an in-well vapor stripper will be installed in a DNAPL (TCE) contaminated "hot spot zone", upgradient from a downflow biotreatment well. The TCE will be emplaced in a cell at the Groundwater Remediation Field Laboratory (GRFL) at Dover AFB. In operation, the in-well vapor stripper will use air-lift pumping to pump contaminated water from the lower portion of the aquifer to a screened interval above and below the water table. Approximately 90-99 percent of the VOC will be stripped out of the water into the gas phase, which will subsequently be treated using granular activated carbon. The treated water leaving the upper screen of the in-well vapor stripper will flow to the upper screen of the biotreatment well. Water entering the biotreatment well will be pumped down through the well, where a primary substrate such as toluene will be added. Oxygen may also need to be added in the biotreatment well, though it is possible that the oxygen dissolved during the in-well vapor stripping will be sufficient to support the aerobic bioremediation process. After addition of the primary substrate (and possibly, oxygen), the water will be injected into the aquifer through the lower screened interval, where indigenous microorganisms can aerobically metabolize the primary substrate and cometabolize the contaminant. A portion of the water leaving the bioactive zone will recirculate back to the lower screen of the in-well vapor stripper for further treatment. We believe the combined technology of bioenhanced in-well vapor stripping will remove aster when compared to conventional technologies (e.g., pump-and-treat).

Operation of the technology will be monitored using an extensive system of wells, connected to an automated sampling and analysis systems. This monitoring technique has proven capable of inexpensively providing the large amounts of data needed to monitor the performance of an in-situ remediation technology.

Because each technology is currently being demonstrated independently, the main technical challenge and risk comes from the integration of the two, which can be dealt with by adjusting various operating parameters (e.g., gas flow in the stripping well, primary substrate feed in the biotreatment well, water flow rates) to optimize performance. Another challenge will be to scale down the two technologies (in-well vapor stripping and in-situ bioremediation), which are currently being demonstrated at full-scale in the field at Edwards AFB, for analysis within the confines of a GRFL cell. This scaling-down will be accomplished through modeling, by combining fate and transport models that have been developed to simulate the two technologies. A last challenge will be to demonstrate the system at a site that has geochemical conditions considerably different from the conditions encountered at Edwards AFB. In particular, the high iron content in the groundwater at the GRFL may present difficulties that may require adjustments to the system.

BENEFIT: The most obvious benefit is that this combination of technologies offers the potential of reducing, in situ, contaminant concentrations at a DNAPL contaminated site over three orders of magnitude, something which heretofore has never been demonstrated. The fact that the technologies are applied in situ minimizes risk to human and environmental receptors, as well as reduces the costs of pumping water to the surface, treating it, and disposing of it. The technologies can be used at sites with any volatile, separate-phase contaminant that is susceptible to bioremediation by aerobic cometabolism (TCE, DCE, vinyl chloride, dichloromethane, etc.).

FY 1997 Milestones	Planned Date
1. MIPR funds to EPA	12/01/96
2. EPA forward funds to WRHSRC	02/01/97
3. Characterize site hydrogeologically, chemically, and microbiologically	07/01/97
4. Develop model and run simulations	08/01/97
5. Design demonstration and complete workplan	09/01/97
6. Interim Report	10/01/97

PROJECT SUMMARY

PROJECT TITLE & ID: Low Frequency Ultra-Wideband (UWB) Synthetic Aperture Radar (SAR) for Remote Detection of Unexploded Ordnance (UXO); CU-1070

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: U.S. Army

LAB: Army Research Laboratory - Adelphi, MD

PRINCIPAL INVESTIGATOR: Mr. Vince Marinelli

FY 1997 FUNDS: $500K

OBJECTIVE: The goals of this project are: 1) to determine the applicability of low-frequency ultra-wideband (UWB) SAR for detecting and discriminating surface and subsurface UXO; 2) to refine and validate electromagnetic models that can be used to extrapolate UWB SAR performance to other environmental conditions (soils); and, 3) to develop detection algorithms for separating UXO from clutter.

Currently, methods for detecting unexploded ordnance (UXO) involve laborious ground surveys that are slow, dangerous, and impractical for dealing with vast UXO-contaminated lands. Advanced technologies are required which are quicker, safer, and more cost-effective than current approaches. Synthetic aperture radar (SAR) is an advanced technology that offers significant potential for quickly and safely detecting UXO.

TECHNICAL APPROACH AND RISKS: ARL will use their precision measurement asset, called the BoomSAR, in the execution of this project. The BoomSAR is a fully polarimetric radar that operates across a 1-GHz-wide band, from 25 MHZ to 1 GHz. This bandwidth contains low frequencies needed for ground penetration, while maintaining higher-frequency coverage for high-resolution imagery. The ultra-wide bandwidth provides measured range resolution of 0.15 m; the aperture length provides cross-range resolution of 0.15 m. The radar is mounted on a boom-lift that can operate at heights of 5 to 45 m while moving at 1 km per hour, allowing the radar to operate in a strip-map SAR mode.

ARL's BoomSAR will be used to collect high-quality precision data to support phenomenological investigations of electromagnetic wave propagation through dielectric media. These investigations, in turn, will support the development of algorithms for target detection. Data will be collected at two UXO test sites that have been seeded with a comprehensive variety of inert UXO.

ARL has already established at Yuma Proving Ground a dedicated test site where the Boom SAR can collect data against inert targets. For this SERDP project, several hundred UXO targets will be added to the test site and full ground truthing will be conducted. In September, 1997, the BoomSAR will collect data against the UXO target set. Image formation and processing of this data will take place in FY 1998. A second test site will be selected for a BoomSAR data collection in FY 1998. Site selection and initial planning activities will be performed in FY97.

This project is minimizing technical risk by leveraging the significant investments of ARL's 6.2 Army tech base and Defense Intelligence Agency customer funds. The Army Research Laboratory has played a significant role in understanding the potential of low-frequency, ultra-wideband synthetic aperture radar (UWB SAR) technology to detect targets concealed by foliage and subsurface targets. In addition, ARL has been working closely with other agencies, such as Defense Advanced Research Projects Agency, Air Force Wright Labs, Naval Surface Weapons Center, Defense Special Weapons Agency, and Defense Intelligence Agency, to realize the full potential of this advanced technology.

BENEFIT: Potential users of this technology include active test and training ranges, BRAC and FUD sites, and numerous foreign countries requiring advanced technologies for locating UXO. The knowledge gained by this effort will significantly enhance our understanding of the phenomenology of UXO characterization using low-frequency UWB SAR. This effort will also help to determine the utility of the ARL BoomSAR for surveying large regions and detecting and discriminating various surface and subsurface UXO. It is expected that this technology will achieve rapid survey speeds/coverage rates while allowing safe standoff distances during operation; it will also significantly improve the detection, monitoring, and risk management activities at cleanup sites.

FY 1997 Milestones		Planned Date
1.	Tri-Service Coordination of UXO Target Set at Yuma Test Site	04/30/97
2.	Generation of Test Plan	06/30/97
3.	Complete EIS	06/30/97
4.	UXO Target Emplacement	08/31/97
5.	Soil Characterization	08/31/97
6.	BoomSAR Data Collection	09/30/97
7.	Second Test Site Selection	07/31/97
8.	Initial Soil Characterization at Second Test Site	09/30/97
9.	Processing of Preliminary UXO Data	07/31/97

PROJECT SUMMARY

PROJECT TITLE & ID: Unexploded Ordnance (UXO) Detection by Enhanced Harmonic Radar; CU-1071

RESEARCH CATEGORY: 6.3 Advanced Development

LEAD AGENCY: National Reconnaissance Office

LAB: National Reconnaissance Office - Chantilly, VA

PRINCIPAL INVESTIGATOR: Dr. Ronald Stocks

FY 1997 FUNDS: $460K

OBJECTIVE: The objective of this effort is to design, fabricate and test a third harmonic radar to determine its efficiency in; a) detecting surface and buried mines of all sizes and types; and, b) detecting surface and shallow-buried UXO. In addition, the radar also will produce a capability to produce high resolution images showing their locations. This proposal builds on earlier work on harmonic radar and outlines the development and demonstration of a high resolution, medium range (3-4 km standoff distance) impulse driven synthetic aperture radar.

The problem of mine and UXO detection has become both acute domestically and worldwide. It is estimated that over 110 million mines exist in 68 countries and UXO problems cannot be accurately estimated. In the US specifically, there are over 900 sites (11 million acres) of potentially UXO contaminated land of varying terrain, foliation, and topography (including 50 underwater sites). UXO cleanup represents a huge and costly problem. To date, methods of detection and remediation are at best slow and expensive and at worst crude and highly dangerous. The advantage of improved target detection techniques (especially airborne) that can aid in rapid, cost efficient and safe detection are obvious.

Traditional radar methods have been tried with limited success and are frequently rendered ineffective by the presence of high ground clutter (rocks, debris) in an image that generates a high false alarm rate. In addition, anti-personnel mines frequently are too small to be detected.

The project is divided into two phases, a ground phase and an airborne phase. The final result of this effort will be a prototype third harmonic radar system hosted on an aircraft for the detection and mapping of surface and subsurface mines and UXO. This system will be available for operational deployment if desired.

TECHNICAL APPROACH & RISK: The critical elements of thie ability to produce usable images for analysis and the fusion of this information with that from other sensors. The major reason that GPR and other radars have not lived up to some expectations is not because of the lack of power, resolution or penetration capabilities. Rather, the problem lies with the lack of

specificity of the radar return. Natural clutter, depressions, soil strata, etc., produce their own returns that mask, obscure or compete with those targets of interest. Unlike higher frequency radars, typical foliage and ground penetrating radars produce images that are so cluttered that they are difficult to interpret, For example, prior mine detection tests produce images that are so cluttered that they are difficult to interpret. For example, prior mine detection tests in a desert environment were successfully detected and imaged. However, if the mines had not been laid out in a recognizable pattern that was known a priori, the mines would be difficult to discriminate from the natural clutter in the image.

Image discriminants have proved elusive and even highly sophisticated ATR algorithms have difficulty in discrimination. Third harmonic radars provide that discriminant. The unique radiation characteristic potentially can be exploited to completely suppress the natural clutter.

The production of images that detect and accurately locate targets of interest has not been previously attempted. However, several years of effort with other radar systems have produced a wealth of image processing algorithms that will form the foundation of the image processing requirement. In addition, this project intends to make use of the SERDP National Environmental Technology Test Sites to the maximum degree possible.

BENEFIT: The immediate benefit to be realized from this effort is a prototype system with a demonstrated capability to remotely detect and locate surface and shallow-buried mines and UXO. The radar system will be capable of standoff "broad area" search at relatively low cost and provide greater efficiency in removal and/or cleanup. The radar system will be an operational prototype that could be used for subsequent contractor-supported operations. The radar could also be modified to fit on a variety of aircraft of helicopter platforms. In addition, this technology should be of interest to a variety of other DoD/DOE environmental, military and law enforcement objectives.

FY 1997 Milestones	Planned Date
1. Complete CW Chamber Measurements Report	08/10/97
2. Complete UWB Chamber Measurements Report	11/01/97
3. Complete Trailer Measurements Report	01/15/98
4. Complete Final Report - Phase I	02/01/98

APPENDIX B

Compliance Project Summaries

PROJECT SUMMARY

PROJECT TITLE & ID: Shipboard Non-Oily Wastewater Treatment System; CP-29

RESEARCH CATEGORY: 6.3 Advanced Development

LEAD AGENCY: U.S. Navy

LAB: Naval Surface Warfare Center - Annapolis, MD

PRINCIPAL INVESTIGATOR: Mr. John Benson

FY 1996 COMPLETED PROJECT

OBJECTIVE: To develop a process to treat graywater prior to discharge to meet the anticipated effluent quality requirements of the U.S. EPA and MARPOL Annex IV.

BENEFIT: The graywater treatment process will be suitable for backfit into existing DoD surface ships.

ACCOMPLISHMENTS: Membrane filtration was selected as the most viable treatment option that will meet anticipated discharge standards. It is affordable (with respect to capital, logistics, manpower), compact (space and weight), reliable and safe. A first-generation, membrane-based graywater treatment system was demonstrated successfully in the laboratory using Navy-generated, land-based graywater mixtures. The first stage of the system uses large-bore, polymeric membranes to trap coarse and fine solids and to remove a significant amount of biochemical oxygen demand (BOD) and fecal coliform bacteria. A second-stage nanofilter enables the system to remove dissolved organics and further reduce the effluent concentrations of BOD and suspended solids. Tests also were conducted on graywater from USS L.Y. SPEAR while pierside at Norfolk Naval Base where a 3 gal/min prototype unit was evaluated for 850 hours. Results showed that the membrane system can potentially meet anticipated U.S. and International discharge standards for graywater.

TRANSITION: In consultation with membrane experts from academia and industry, the Navy will use data from these pierside tests to determine the final design parameters for a shipboard graywater treatment system. The minimization and treatment of shipboard, non-oily wastewater will be further addressed by two new SERDP initiatives planned for FY 1998, one in the Compliance thrust area and the other in Pollution Prevention.

PROJECT SUMMARY

PROJECT TITLE & ID: Compact, Closed-Loop Controlled Waste Incinerator; CP-34

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: U.S. Navy

LAB: Naval Air Warfare Center - China Lake, CA

PRINCIPAL INVESTIGATOR: Dr. Klaus Schadow

FY 1997 FUNDS: $900K

OBJECTIVE: This project will establish the Science and Technology (S&T) basis for a compact, closed-loop-controlled waste incinerator using resonant acoustics for enhanced waste pyrolysis and controlled vortex dynamics for enhanced and controlled afterburning. The afterburning process will be closed-loop controlled using newly developed control components, including diode-laser based sensors for real-time and continuous emission monitoring, new types of actuators, and a non-standard controller based on fuzzy logic or neural nets. A second SERDP project, **CP-887 Demonstration of a Compact, Closed-Loop Controlled Waste Incinerator,** will apply this new technology to two Navy incinerator programs (see Project Summary for CP-887 in this Appendix).

TECHNICAL APPROACH AND RISKS: The S&T studies consist of: (1) control component development which includes separate tasks for the development of advanced sensors, actuators, a process model and an adaptive controller; and (2) sub-scale evaluation and integration. Sub-scale experiments with advanced laser diagnostics are being conducted to: evaluate both the trapped-vortex and periodic-vortex concepts; validate control components; and integrate control components. The effectiveness of the new closed-loop controlled system will be compared to existing incinerator technologies in terms of compactness and emission characteristics. These sub-scale integration tests will further define the requirements and design criteria for full-scale demonstration and optimization of the sludge incinerator and the plasma arc afterburner in SERDP project **CP-887**.

ACCOMPLISHMENTS: This project developed two specific technologies to improve combustion characteristics of solid and liquid wastes. The first technology applied resonant acoustics to the primary combustion chamber to enhance the burning rate of solid beds and improve the burning characteristics of liquid sprays. The advantages of resonant acoustics for enhancing the pyrolysis processes were demonstrated in simulated solid-waste experiments and are presently being applied to a black water sludge incinerator. The second technology applies active combustion control to the secondary chamber to achieve efficient and controlled afterburning in acoustically stabilized vortices. The active control technology, which was successfully scaled up by a factor of 200 to a 1 MW afterburner simulator,

significantly increased the destruction and removal efficiency (DRE) of a waste surrogate, while greatly reducing emissions of unburned hydrocarbons, CO, and NOx. Advanced diode laser-based sensors, actuators, and control strategies were developed to implement this new technology. The controlled afterburner concept is applicable to a variety of waste treatment and combustor systems.

BENEFIT: Successful demonstration of a compact incinerator with real-time exhaust monitoring for active combustion control represents a significant step towards assured waste incineration and can be the basis for the next-generation incinerators. The compact-incinerator technology will be demonstrated for specific shipboard application, and will be essential for the development of environmentally sound ships beyond the year 2000. Compact incinerators also are desirable for on-shore use in the government and private sector. Small, compact incinerators will allow on-site waste destruction and avoid waste transportation to large incineration sites. In particular, medical waste incineration is a prime candidate in the private sector for a compact incinerator system. The closed-loop active control of the incineration process will,for the first time, assure proper incineration. Assured waste incineration on-board ships will result in significant cost savings by avoiding cost for waste off-loading and on-shore destruction, in particular in foreign countries.

FY 1997 Milestones	Planned Date
1. Feasibility of Diode-Laser Sensor in 50 KW Combustor Demo	03/31/97
2. Large Eddy Stimulation Scale-up to 1MW Afterburner Completed	03/31/97
3. Reactor for Destruction and Removal Efficiency (DRE) and Byproduct Identification Completed	04/30/97
4. Initial Testing of Sludge Inc. with Pulse Combustor Completed	04/30/97
5. BTU and A/F Effects on 50 KW Afterburner Performance Studied	06/30/97
6. Evaluation of Advanced Air Actuator Completed	06/30/97
7. Diode-Laser Sensor Integrated in Control Loop (50 KW Afterburner)	07/31/97
8. Optimization of Afterburner using LES based 1D Model Complete	08/31/97
9. DRE Measurement and Byproduct Identification Completed	09/30/97
10. Experimental System Identification of 50 KW Afterburner Completed	09/30/97
11. Fuzzy Logic Control into LES 1D Model Integrated	09/30/97
12. New Diode-Laser Strategies for CO+C6H6 Measurement Identified	10/31/97
13. Benefits of Pulse Contamination on Sludge Incineration Identified	12/31/97
14. Kinetic Modeling of Byproduct Yield Completed	12/31/97
15. Controller for Closed-loop Control Selected	12/31/97

PROJECT SUMMARY

PROJECT TITLE & ID: Reduction of NOx Emissions from Marine Power Plants; CP-42

RESEARCH CATEGORY: 6.4 Demonstration and Validation

LEAD AGENCY: U.S. Navy

LAB: Naval Surface Warfare Center - Annapolis, MD

PRINCIPAL INVESTIGATOR: Dr. Herman Urbach

FY 1997 FUNDS: $400K

OBJECTIVE: The Navy has been directed by to make a good-faith attempt to comply with anticipated, state-imposed limits on emissions from a naval inventory of about 700 gas turbines and 2,700 diesel engines on ships operating within coastal waters. One low-risk, low-cost, state-of-the-art development achieves low-NOx emission from gas turbines by injecting water into the gas-turbine combustor. For diesel engines, simultaneous use of injection timing retardation, exhaust-gas recirculation, and water injection appear necessary to achieve anticipated state-imposed emission standards. The impact of these emission-reducing technologies on complicated ship engines, including their ability to operate without unscheduled loss of power in a tactical situation may be assessed only through realistic shipboard evaluation. It is the objective of this project to establish within the Navy community, the credibility of these technologies as an acceptable method of reducing NOx emissions from Navy engines in a naval, at-sea operating scenario.

TECHNICAL APPROACH AND RISKS: A water-injection controller (WIC), designed and fabricated for injection of water into the combustor of an LM2500 gas turbine will be tested at the LM2500 test and land-based simulation facility at NAVSSES in Philadelphia. Pending successful resolution of these tests, and management concurrence, the WIC system will be installed on an FFG-Class ship at the Norfolk shipyard. After ship integration, the WIC system and its automated emissions monitor will undergo at-sea testing to assess the overall impact of the WIC system on the gas-turbine plant and ambient ship systems.

A DDC 4-71 diesel engine will be modified to retard the timing of fuel injection, to introduce exhaust gas recirculation and to inject water in the form of an emulsified, fuel-water mixture. The manually-controlled system will be tested at research facilities of the North Carolina State University prior to any testing in a Yard Patrol (YP) ship at Annapolis. Studies will assess the risks of erosion/corrosion in the fuel injectors, flame quenching and/or cylinder misfiring. The at-sea test in the YP will assess all ship-system impacts.

ACCOMPLISHMENTS: In FY 1996, a manually-controlled water-injection combustor (WIC) installed at a land-based LM2500 engine facility successfully reduced NOx emissions in the

effluent gases to the proposed mandate levels of 42 ppm. An automatic WIC system for injecting water into the combustor of gas turbines was then designed, fabricated, tested , and integrated into the LM2500 engine using the existing (simplex) fuel manifold. Analysis of the concept of water-fog injection into the compressor inlet, which might avoid any loss of thermodynamic efficiency and increase gas-turbine power output, was also initiated.

BENEFIT: This project will allow the Navy to operate as an ecologically benign neighbor in domestic and global maritime environments. It will permit the Navy to avoid litigation and to operate in zones subject to strict limitations of NOx emissions, such as the California littoral and congested European ports.

FY 1997 Milestones	Planned Date
1. Test WIC System with the Duplex Fuel Manifold	09/30/96
2. Go/No-Go Decision for the WIC-System At-Sea Test	11/15/96
3. Complete Modification Plan for Diesel NOx Reduction	11/30/96
4. Formulate Ship Installation Plan of the WIC System	01/30/97
5. Land-Based Test of the Diesel NOx Reduction System	04/15/97
6. Install the WIC System aboard a Frigate	04/30/97
7. Fabricate Diesel Modification System	06/30/97
8. Formulate Ship Installation Plan for the Diesel System	07/30/97
9. Install Diesel Modification System aboard the Frigate	09/30/97
10. Start Shipboard Tests of the WIC System	09/30/97

PROJECT SUMMARY

PROJECT TITLE & ID: Emission Reduction Planning Model; CP-175

RESEARCH CATEGORY: 6.3 Advanced Development

LEAD AGENCY: U.S. Air Force

LAB: Armstrong Laboratory - Tyndall Air Force Base, FL

PRINCIPAL INVESTIGATOR: Major Carolyn Vadnais

FY 1997 FUNDS: $350K

OBJECTIVE: This project will develop an Emission Reduction Planning Model (EPRM), an integrated emissions-dispersion database and expert decision system to aid environmental planners and air pollution managers in reducing criteria and hazardous air pollutant (HAP) emissions at Air Force and Army installations. Complying with, and moving beyond, the requirements of the 1990 Clean Air Act Amendments and evolving Federal/State/local regulatory standards will be very difficult with the current myriad of non-standardized approaches. A system combining air quality impact assessment with rule-based algorithms for determining optimal reduction and control strategies will enable the Air Force and Army to apply cost-effective control and mitigation techniques in a consistent manner. Once finalized, the software will be transitioned to the Air Force Center for Environmental Excellence (AFCEE) for distribution and implementation at facilities nationwide.

TECHNICAL APPROACH AND RISKS: The approach for this project consists of five milestones to be accomplished with the FY 1997 funding. The first milestone will add compliance strategies to ERPM that are alternative to "end-of-tailpipe" control techniques, such as pollution prevention techniques. The second milestone involves linking advanced dispersion models to the ERPM as well as providing the user with the rules of thumb for using the models and interpreting the results. The third milestone involves a field test of the ERPM model, including independent validation of the ERPM methodologies, data structures and user interface by experts in the field as well as by the ultimate end users of the ERPM (i.e., DoD environmental coordinators). The fourth milestone involves modifying the ERPM based on internal and external feedback obtained during the phase II field test of the model. The fifth milestone involves completing a version of the ERPM that contains all of the analytical capabilities developed specifically for the ERPM.

ACCOMPLISHMENTS: In FY 1996, the emission inventory database interface was completed, which allows the ERPM software to extract and analyze emissions inventory data from a variety of existing software packages. The SCREEN3 dispersion screening model was incorporated to provide a conservative estimate of ambient pollutant concentrations. Phase I

testing of the ERPM computer model was conducted with representative Army/Air Force users to evaluate its utility in selecting emissions control technologies.

BENEFIT: A system combining air quality impact assessment with rule-based expert algorithms for determining optimized reduction and compliance strategies will enable the Air Force and Army to apply cost-effective control and mitigation techniques in a consistent manner. Man-hours and expense involved in selecting and implementing high-impact emissions reduction programs will be reduced as a result. The resulting software may have substantial application potential at other federal and private facilities.

FY 1997 Milestones		Planned Date
1.	Incorporate Alternative Compliance Strategies into ERPM	12/01/96
2.	Complete Advanced Dispersion Model Interface with ERPM	02/01/97
3.	Complete Phase II Field Test of ERPM	04/01/97
4.	Modify ERPM per Phase II Feedback	07/01/97
5.	Complete Software/Documentation/Final Report	11/01/97

PROJECT SUMMARY

PROJECT TITLE & ID: Metal Perovskite Catalysts for NOx Reduction; CP-177

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: U.S. Air Force

LAB: Armstrong Laboratory - Tyndall Air Force Base, FL

PRINCIPAL INVESTIGATOR: Dr. Joseph Wander

FY 1997 FUNDS: $90K

OBJECTIVE: The overall objective of this project is to investigate the use of a strontium-lanthanum cobaltate catalyst for reduction of oxides of nitrogen (NOx) in high-temperature environments such as high-performance jet engines and exhaust manifolds of diesel or gasoline engines. The thermodynamics and kinetics of reduction of strontium-lanthanum cobaltate in NOx and the limits of stability of the active, oxygen-deficient phase will be determined to establish its long-term effectiveness as a catalyst for reduction of NOx. This project consists of three stages of 6.2 basic research of which the FY 1997 portion is stage 3. This effort, if successful, will result in a treatment technology for NOx emissions from military and commercial jet engines. The results of the 6.2 basic research will be used in a follow-on 6.3 technology demonstration effort where catalyst performance in controlling emissions from an operational combustor will be demonstrated at an Air Force facility. Favorable results would allow technology transfer to the Turbine Propulsion Office (WL/POSC) for further development and fielding.

TECHNICAL APPROACH AND RISKS: All basic research for this continuing effort are on the laboratory scale, including simulation of representative exhaust streams. The thermodynamics and kinetics of reduction by the metal perovskite catalyst are being analyzed using techniques involving thermogravimetric analysis, differential scanning calorimetry and the use of high-temperature electrochemical cells to measure oxygen activity. Thermodynamic and kinetics of phase equilibria of the oxygen-deficient phase are being modeled and reported. The medium-level technical risks in the research include the following: (1) It may be difficult to control the degree of reduction of the catalyst, resulting in short lifetime (and poor economics); and (2) The catalysis of NOx may be too slow to act as a fast catalyst needed for current applications. The first risk carries double weight, as the spent catalyst may not be regenerable and would have to be disposed of as a hazardous, heavy-metal waste. The critical path is evaluating the stability of the metal perovskite catalyst as a long-term NOx-reducing agent. If the results are negative, they will be published and no further work pursued using strontium-lanthanum cobaltate catalysts to reduce NOx emissions in high-temperature environments.

ACCOMPLISHMENTS: In FY 1996, preliminary testing of catalytic activity was completed. NOx-removal was observed for dry, oxygen-free gases at about 300C. Laboratory tests are ongoing to establish the effects on NOx-removal of temperature and concentrations of water, oxygen, and carbon monoxide (CO). Evaluation of material fabrication for reactor design was also conducted.

BENEFIT: The benefit derived from this research will be the determination of the feasibility and economics of using strontium-lanthanum cobaltate catalysts for reduction of NOx in high-temperature environments. The advantage of using this transition metal as a catalyst is a significant cost savings over noble metals such as platinum. Technology can be transitioned to private sector industries such as aviation and internal combustion engine manufacturers. This supports the SERDP R&D objective of developing treatment technologies for installation support operations.

FY 1997 Milestones	Planned Date
1. Fabricate Strontium-Lanthanum Cobaltate Catalyst Coat on Yttria-Stabilized Tubes (YSZ)	02/01/97
2. Final Checkout of Reactor	04/01/97
3. Map Extent of Removal of NO vs Temperature, [CO], [O_2], in Reactor for SrLaCoOx on YSZ	09/01/97
4. Final Report	10/01/97

PROJECT SUMMARY

PROJECT TITLE & ID: Advanced Mass Spectrometry for Atmospheric Monitoring; CP-192

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: U.S. Air Force

LAB: Phillips Laboratory - Kirkland Air Force Base, NM

PRINCIPAL INVESTIGATOR: Dr. John O. Ballenthin

FY 1997 FUNDS: $600K

OBJECTIVE: This applied research effort is developing and demonstrating technology to measure the concentrations of trace gas-phase neutral species in the stratosphere, troposphere, and ground level atmosphere. This technique is broadly applicable to the SERDP Compliance pillar by providing an effective, robust, portable apparatus capable of detecting major and minor pollutants with greater than a trillion-to-one dynamic range and part-per-quadrillion sensitivity.

TECHNICAL APPROACH AND RISKS: This effort is capitalizing on the chemical reactions between neutral pollutant gas molecules and naturally present, atmospheric ions which often produce new ion species that are unique signatures of the original trace neutral. Because of the very small background signal level for ions, the technique routinely provides sensitivities to detect neutrals in the parts-per-quadrillion levels. Risks have been minimized since the concept has been developed and proven by laboratory measurements. The prototype mass spectrometer has already been demonstrated to function in upper tropospheric and lower stratospheric measurements of jet engine exhaust composition. The critical path to program completion will be: develop and demonstrate the capability of a portable system for jet, rocket and other plume measurements with comparisons with competing instrumentation; demonstrate the capability of the system for analysis of complex pollutant mixtures present in such sources as jet engines test cells and stack processes; and perform laboratory measurements of trace neutral ion chemistry of relevant species.

ACCOMPLISHMENTS: In FY 1996, prototype mass spectrometers were used in three experiments aimed at resolving environmental issues of interest to the Air Force:

(1) A lightweight, portable, prototype spectrometer was integrated into a WB-57 high altitude research aircraft and flown through the exhaust plumes of Titan IV launch vehicles to investigate whether deposition of HCl in the stratosphere by Titan IV solid rocket plumes might lead to local catalytic destruction of the ozone layer. HCl, Cl, Cl_2, ClO and O_3 were measured in the plumes to investigate the mechanism of ozone depletion by solid rocket exhaust and to assess the degree of ozone depletion attributable to launch operations.

Confirmation of the production of Cl_2 species showed very good agreement with the plume chemistry model.

2) A second prototype was used as part of the large NASA Subsonic Aircraft: Contrail and Cloud Effects Special Study (SUCCESS) effort, which examined the impact of jet engine exhaust on upper troposphere/lower stratosphere chemistry and energy balance, and on the properties and mechanisms of cloud and contrail formation. The mass spectrometer was installed in a T39 jet, which was flown in close formation behind DC-8 and 757 lead aircraft. Gas phase HNO_2, HNO_3, SO_2 and H_2SO_4 concentrations in jet exhaust plumes were measured to assess the role of these species in heterogenous or binary nucleation and subsequent contrail formation.

3) A prototype spectrometer was used at the Air Force's Wright Laboratory to measure the gas species produced when conventional fire suppressants such as Halon 1301 and various next-generation suppressants were injected into flames. The data will be used to assess the safety of proposed halon replacements before they are used in flight line or field applications and to evaluate flame suppression.

BENEFIT: This research program will lead to high sensitivity measurements of the concentrations of many species at ground level and in the troposphere and stratosphere. Models of the chemistry of polluted environments can then be improved by adjusting the model to match the measurements. The validated models can then be applied with confidence to environmental scenarios where direct measurements have not been made. An immediate benefit of the research will be to ensure compliance of jet- or rocket-engine emission with mandated standards and to support DoD efforts to reduce pollution from jet and rocket operations. The end-product of the research will be a portable, highly sensitive, calibrated, and tested instrument that will be suitable for commercialization and use by the environmental monitoring community.

FY 1997 Milestones		Planned Date
1.	First Test of High Pressure Turbulent Flow Tube	01/01/97
2.	Obligate Fund Allocation for Contractual Support	01/01/97
3.	Complete Construction and Test of Non-Licensible Radioactive Ion Source	02/01/97
4.	Complete CO_3-Hydrate Chemistry Related to Jet Engines	03/01/97
5.	First Kinetics Measurements in High Pressure Turbulent Flow Tube	05/01/97
6.	Complete Software for Real Time Data Calculation and Display	06/01/97
7.	Integrate Instrument into Aircraft Platform for Jet Engine Exhaust Sampling	06/01/97
8.	Perform Airborne Jet Exhaust Measurements	08/01/97
9.	Complete NO3-Hydrate Chemistry Related to Jet Engines	08/01/97

PROJECT SUMMARY

PROJECT TITLE & ID: Characterization of Open Burning/Open Detonation (OB/OD) Emissions; CP-247

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: U.S. Army

LAB: Dugway Proving Ground - Dugway, UT

PRINCIPAL INVESTIGATOR: Mr. R.J. Black

FY 1997 FUNDS: $1,380K

OBJECTIVE: This project is part of a program to develop a testing system fully capable of characterizing emissions produced by the open burning/open detonation (OB/OD) of all conventional munitions and energetics within the demilitarization system. This characterization will make the OB/OD disposal process more efficient, reduce the impact of OB/OD operations on the environment, and facilitate the OB/OD permitting process. Computer-simulated emissions data have not been acceped by regulators, requiring that actual OB/OD test emissions data be submitted for Subpart X permits.

TECHNICAL APPROACH AND RISKS: Specific areas have been identified for R&D: (1) Develop and validate testing procedures, acceptable to the U.S. EPA, for characterizing emissions, including developing more efficient sampling and analysis methods for soil and air, determining the effect of soil, evaluation of real-time instruments, and determining the feasibility and effect of using various noise suppression devices. (2) Characterize OB/OD emissions of items in the demilitarization inventory. Also use data to evaluate available models and produce an OB/OD source characterization model and source terms for OB/OD processes. (3) Develop OB/OD Emission Database. Data will be statistically analyzed to determine the feasibility of grouping individual items in the demilitarization inventory into groups based on their OB/OD emissions to avoid testing every individual item. (4) OB/OD process optimization to provide a scientifically sound understanding of the process of destruction of munitions and propellant, explosive, and pyrotechnic (PEP) materials. An increased explosive capacity OB/OD facility (ODOBi), capable of handling items up to 100 times the explosive capacity of the current test facility, will be constructed to provide data that will be used to determine a scaling relationship between the amount of an item tested and the much larger amount used in the actual open air OB/OD treatment of the item. The ODOBi will also allow for the manipulation of the item setup prior to OB/OD treatment in order to determine the effects of item configuration on the emissions produced. This will allow OB/OD technologies to be modernized in order to maximize the conversion of munitions and PEP materials into harmless products while reducing the noise, shrapnel, and blast wave released by OB/OD activities. (5) Develop collaborative efforts within the

Department of Defense, the Department of Energy, and industry. The risks to this approach are that no new test technologies applicable to the OB/OD test project will be identified or that those identified will not improve the test process. Items for characterization of OB/OD emissions will be selected based on their relative quantity within the inventory and from the gaps in the existing OB/OD emissions database.

ACCOMPLISHMENTS: In FY 1996, the emissions database was completed. These data will be analyzed to determine the feasibility of grouping individual items in the demilitarization inventory into groups (classifying munitions by emissions families) based on their OB/OD emissions without having to test every individual item. The OB/OD process was optimized and conceptual design and procurement of the Phase II ODOBi was completed.

BENEFIT: The optimization of the OB/OD treatment process will provide a scientifically sound method for minimizing toxic emissions and sound and pressure waves generated by open-air OB/OD thermal treatment, which is fast, inexpensive, and safe. By providing the technologies to accurately generate OB/OD emissions, and data that can justify continuation of OB/OD operations where appropriate, this project is averting crises of major proportions and will also produce significant cost savings in munitions and PEP disposal. As items suitable for OB/OD disposal are identified, those items unacceptable for OB/OD treatment will likewise be identified, allowing for the focusing of R&D funds for alternate disposal technologies where the need is greatest.

	FY 1997 Milestones	Planned Date
1.	ODOBi facility delivered to Dugway Proving Ground (DPG) and installed	11/01/96
2.	Characterization and acceptance testing of ODOBi completed using PEP representative of demil inventory	02/01/97
3.	Study on the effect of oxygen deprivation and enrichment on OD processes completed	04/01/97
4.	Study on the effect of water shroud on OD processes completed	05/01/97
5.	Study on the effectiveness of water jet cutting/low temperature thermite ignition on OD emission completed	06/15/97
6.	Database of emission factors and other source terms for OB/OD processes available	08/01/97
7.	Program to input emission factors into MIDAS available	08/01/97
8.	Final report issued on classification of PEP materials into OB/OD emission product families	09/01/97
9.	Final report containing guidance on optimized OB and OD processes	09/15/97

PROJECT SUMMARY

PROJECT TITLE & ID: Leak Location in Underground Pipelines; CP-249

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: Environmental Protection Agency

LAB: National Risk Management Research Lab - Edison, NJ

PRINCIPAL INVESTIGATOR: Mr. Anthony Tafuri

FY 1997 FUNDS: $115K

OBJECTIVE: The project objective is to develop and demonstrate a non-invasive and non-destructive system for detecting and locating small leaks in pressurized pipelines. The technology must be accurate, simple to use, and applicable to a wide variety of pipelines and products. This technology will be utilized to detect and locate small leaks from the thousands of miles of DoD and DOE pressurized pipelines worldwide. This enables DoD and DOE to comply with environmental and safety regulations.

TECHNICAL APPROACH AND RISKS: The technical approach involves five key steps. An existing pipeline test facility at the EPA Edison, NJ location will be modified by installing additional pipelines to allow the necessary testing. Preliminary experiments will be conducted to characterize acoustic signals associated with leaks and to determine the acoustic effects of factors such as multiple leaks, pipe fittings, corrosion, and backfill. Data from the experiments will be used to develop a prototype test system that will be first evaluated at the test location and then in the field at DoD and DOE locations. The prototype will be modified further to address any problems discovered during the initial field tests and then demonstrated at DoD and DOE locations. A users manual will be prepared and technology transfer activities will be undertaken to provide for rapid commercial availability of the resulting technology. Technical risks include the possibility of being unable to resolve problems with signal/noise ratio, signal attenuation due to type of product and pipeline environment, and signal transmission due to pipeline configuration and materials of construction. The critical path is the timely design and installation of the experimental pipeline systems.

ACCOMPLISHMENTS: Preliminary experiments were conducted to characterize acoustic signals associated with leaks and to determine the acoustic effects of factors such as multiple leaks, pipe fittings, corrosion, and backfill. Data from the experiments are being used to develop a prototype test system that will be first evaluated at the test location and then in the field at DoD and DOE locations.

BENEFIT: The successful completion of this project benefits DoD and DOE by providing technology to assure rapid compliance with regulatory requirements. The ability to quickly locate leaks in critical pipelines insures a state of readiness on the part of DoD facilities to fulfill their missions. For example, a forced shutdown of fuel handling operations due to leaks would immobilize military equipment and delay transport of military personnel and equipment. The timely detection and location of leaks will reduce the costs of environmental cleanups, mitigate legal liabilities due to damages, and maintain good community relations.

	FY 1997 Milestones	Planned Date
1.	Initiate Field Evaluation of Prototype Portable System	12/31/96
2.	Complete Rest of Modifications to Test Apparatus	12/31/96
3.	Modify Portable System and Evaluate Under Controlled Conditions at Test Apparatus	03/31/97
4.	Demonstrate Modifies Portable System at DoD and DOE Facilities (including Evaluation of User's Manual)	09/30/97
5.	Develop Prototype On-Line System	06/30/97
6.	Modify On-Line System and Evaluate Under Controlled Conditions at Test Apparatus	12/31/97
7.	Demonstrate Modified On-Line System (User's Manual at appropriate DoD and DOE facilities)	12/31/97
8.	Fulfill Technology Transition Plan	12/31/97

PROJECT SUMMARY

PROJECT TITLE & ID: Measuring and Modeling for OB/OD Permitting; CP-251

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: Environmental Protection Agency

LAB: National Risk Management Research Laboratory - Research Triangle Park, NC

PRINCIPAL INVESTIGATOR: Dr. William J. Mitchell

FY 1997 FUNDS: $250K

OBJECTIVE: The objective of this project is to develop a mobile meteorological observation platform and air pollution dispersion model which can be used to predict the impact of open burning and open detonation (OB/OD) of demilitarized munitions on human health and surrounding ecosystems. If successful, the observation and modeling techniques developed in this project will help to significantly reduce the demilitarized stock pile in a timely, cost-efficient manner that is environmentally safe.

TECHNICAL APPROACH AND RISKS: This project is a cooperative effort involving the EPA, the National Oceanic and Atmospheric Administration's (NOAA) Environmental Technology Laboratory (ETL) and Atmospheric Sciences Modeling Division (ASMD), and the US Army's Dugway Proving Grounds (DPG). The first task is to construct the mobile meteorological observation platform (MAOP) comprised of commercially available sensors. These instruments include a wind-profiling radar (tunable between 915 and 924 MHZ) to obtain horizontal and vertical wind profiles from heights of 125 m above ground up to 3000 m over 100 m intervals; and radio acoustic sounding system (RASS) for the acquisition of virtual air temperature profiles from 125 m up to 1500 m intervals; an acoustic sodar system to obtain high resolution (25 m) horizontal and vertical wind profiles in the first 500 m of the boundary layer; a ceilometer (lidar) system to estimate mixed layer height; and at least one (and possibly more) 10 m tower system to obtain surface layer measurements of wind speed and direction, air temperature, relative humidity, solar radiation, barometric pressure and turbulence variables such as fluxes of sensible heat and momentum. The MAOP will be designed in a modular fashion that will allow for future integration of more sensors if needed. This integrated system will provide real-time, meteorological measurements to characterize dispersion of OB/OD emissions. The second task is to develop an air pollution transport and dispersion model specifically designed for OB/OD activities. The model will have the capability of being used at sites with either simple or complex terrain. The model will use the real-time data from the MAOP and data from a database of expected pollution emission factors which will be produced by OB/OD. The source characterization work is being conducted by DPG. Data from the MAOP will be validated against data from a

network of surface and ground-based remote sensors in the Denver Brown Cloud Study. This network will be located in the front range of the Rocky Mountains around Denver, Colorado.

ACCOMPLISHMENTS: In FY 1996, components for the MAOP, which is a modular system comprising a tower(s) and commercially available sensors including wind-profiling radar, radio-acoustic sounding, acoustic sodar, and lidar, were integrated and testing was begun. Operational model algorithms for instantaneous and quasi-continuous plumes, and for mixed layer depth detection were developed.

BENEFIT: This project will provide DoD and DOE tools to acquire the information needed to obtain a RCRA Subpart X permit for OB/OD activities. Use of the MAOP and OB/OD transport and dispersion model will help to reduce the demilitarized stockpile in a timely, cost-efficient manner that is environmentally safe. OB/OD activities are generally less expensive than other reclamation and/or disposal methods, therefore, a substantial savings in cost should also be realized

FY 1997 Milestones	Planned Date
1. Final integration of MAOP components into unified system and installation in mobile trailer	10/01/96
2. Mixed layer height algorithm installed in MAOP computer system	11/01/96
3. Computer code to generate meteorological data input file for OB/OD model installed in MAOP	12/01/96
4. Field evaluation of MAOP performance completed	02/01/97
5. Draft users's guide for MAOP completed	03/01/97
6. New plume rise/dispersion algorithms installed in OB/OD model	03/01/97
7. Performance of OB/OD model characterized against existing data sets and convective tank experiments	07/01/97
8. User's guide for OB/OD model completed	09/01/97

PROJECT SUMMARY

PROJECT TITLE & ID: Vapor Permeation VOC Recovery from Refueling and Storage Operations; CP-252

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: Environmental Protection Agency

LAB: National Risk Management Research Laboratory - Cincinnati, OH

PRINCIPAL INVESTIGATOR: Dr. Subhas Sikdar

FY 1997 FUNDS: $100K

OBJECTIVE: The objective of this project is to develop a cost-effective technology suitable for preventing the loss of fuel hydrocarbon components to the atmosphere during fuel transfer operations, refueling operations, and fuel storage. VOCs in air can be recovered by simple condensation. However, if the concentration of VOCs in the air is dilute, as is the case when VOCs are lost to air during filling a tanker or storage tank, direct condensation would not be economical because of the large air volume involved. Thin-film, non-porous membranes specially made of a hydrophobic resin are capable of recovering VOCs from fuels for direct recycle/reuse. In the vapor permeation process, the VOCs are removed from the VOC-air mixture and condensed back to a liquid phase with very high selectivity. A vacuum is applied and the VOCs are recovered in a condenser. An inert gas sweep also can be used in place of vacuum to achieve similar, and in some cases, superior results.

TECHNICAL APPROACH AND RISKS: Research has been perfromed on the recovery of VOCs, chiefly chlorofluorocarbons (CFCs), from air by the vapor permeation process. This research project will extend this technology to petroleum hydrocarbons to control evaporative fuel emissions. This applied research involves bench-scale laboratory tests to define the separation capability of selected membranes and their performance using various levels of vacuum and inert gas sweep, design and fabrication of a prototype system, field testing at an appropriate DoD facility, and, finally, engineering analysis of the results including a performance analysis to determine cost and payback period.

ACCOMPLISHMENTS: Bench scale evaluation of candidate resin materials in gasoline streams was conducted in a membrane test cell in FY 1996. High removal rates for fuel components were observed.

BENEFIT: Successful development of this technology will provide a cost-effective approach to eliminate a source of hydrocarbon emissions to the atmosphere reducing photochemical smog formation, ozone formation, and evaporation fuel losses during fuel handling and storage. We expect fuel loss avoidance to more than pay for the total costs, including energy

penalty costs, of other control techniques, which would be required to control emissions in areas requiring such controls, particularly California. Implementation of this technology in the civilian sector could alleviate existing pollution levels sufficiently to provide offsets to the military operations, if widely adopted.

FY 1997 Milestones		Planned Date
1.	Complete test site selection	03/15/97
2.	Complete arrangements for site access and support	04/15/97
3.	Complete prototype acquisition	06/16/97
4.	Begin prototype tests	07/15/97
5.	Complete prototype tests	08/30/98
6.	Complete study reports	02/28/98
7.	Complete Technology Transfer Activities	06/30/98

PROJECT SUMMARY

PROJECT TITLE & ID: Encapsulation of Hazardous Ions in Smectite Clays; CP-315

RESEARCH CATEGORY: 6.1 Basic Research

LEAD AGENCY: Department of Energy

LAB: Argonne National Laboratory - Argonne, IL

PRINCIPAL INVESTIGATOR: Mr. Stephen R. Wasserman

FY 1996 COMPLETED PROJECT

OBJECTIVE: This project to develop new and novel materials for the long term storage of hazardous metal ions, particularly those of toxic heavy metal and radionuclides. Current investigations have sought to develop ways to utilize clay minerals as storage media for hazardous cations. The goal of this research is to create modified clays which both encapsulate hazardous ions and resist the leaching of the hazardous waste into the environment. In addition to the creation of such modified clays, a major objective is the characterization of these materials and the verification that they function as intended. These objectives require a significant effort in evaluating the structure and stability of these materials.

BENEFIT: The new clay materials developed by this project constitute the development of a new control technology for hazardous wastes. They offer the possibility of improved long term storage of metallic cations. When native clays are used to filter waste species out of a medium, the resulting immobilized species still require strict storage/disposal control methods, such as hazardous waste landfills. Exposure of such clays to polar slovents that contain other ions can result in the re-exchange of the hazardous waste back into the mobile fluid. Rendering these clays hydrophobic without resorting to charged surfactants will result in materials that are much more resistant to typical environmental stresses. Therefore, less rigorous isolation methods will be required for the long-term storage of these hazardous materials.

ACCOMPLISHMENTS: An improvement of a factor of 20 in the reduction of leaching of the immobilized ion from the hydrophobic clays was observed. Metal ions that have been successfully immobilized in the clays include uranium in the form of uranyl, thorium, lead and copper. Simulation of long-term environmental stresses through the use of hydrothermal conditions demonstrated that reduction and aggregation of the stored ion can occur.

TRANSITION: DOE has filed a patent application for the materials and methods developed in this project, and has made presentations at several national and international technical conferences.

PROJECT SUMMARY

PROJECT TITLE & ID: Waste Forms Based on Separations Media; CP-360

RESEARCH CATEGORY: 6.1 Basic Research

LEAD AGENCY: Department of Energy

LAB: Pacific Northwest Laboratory - Richland, WA

PRINCIPAL INVESTIGATOR: Dr. Bruce Bunker

FY 1996 COMPLETED PROJECT

OBJECTIVE: To determine the feasibility of alternative glass or ceramic waste forms for the containment of TiO_2-rich and phosphate-rich wastes, which, unless they are greatly diluted, are either insoluble or incompatible with the baseline borosilicate glass currently proposed for the containment of radioactive wastes.

BENEFIT: Less dilution of the wastes of concern would reduce the volume of stabilized, immobilized, radioactive waste glass that must be stored, resulting in substantial cost and storage capacity savings. The silicotitanates and iron phosphate glasses developed in this project together could provide suitable waste forms to handle over 90 percent of the radioactive wastes at the DOE Hanford site.

ACCOMPLISHMENTS: Two new cesium silicotitanate zeolites with unique crystal structures that encapsulate cesium in covalently bonded molecular cages were discovered. These zeolites can be used as an ion exchanger to separate aqueous Cs ions and can then be further thermally processed to a stable waste form. Both of these zeolites, as well as several other glass and ceramic compositions, are highly durable and would serve as viable waste forms for containment of Cs sorbed onto silicotitanate ion exchangers. Iron phosphate glass was identified as an alternative host for phosphate and iron-rich tank waste and for cesium chloride and strontium fluoride capsule waste. Iron phosphate glasses were also shown to dissolve 30 percent (by weight) cesium chloride or strontium fluoride while maintaining exceptional durabilities (20 to 50 times better than borosilicate glass).

TRANSITION: This technology is targeted for remediation of waste at DOE sites. Also, potential applications exist in the areas of ion exchange and catalysis.

PROJECT SUMMARY

PROJECT TITLE & ID: Laser Ablation/Ionization Characterization of Solids; CP-362

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: Department of Energy

LAB: Pacific Northwest Laboratory - Richland, WA

PRINCIPAL INVESTIGATOR: Dr. Steven D. Colson

FY 1997 FUNDS: $260K

OBJECTIVE: The objective of this project is to develop general and sensitive techniques for determining the molecular speciation of organics and inorganics in tank wastes and those chemisorbed on mineral soil substrates. These methods must be sensitive to a broad spectrum of compounds to detect the many species present in mixed waste environments. Development of multiphoton-ionization techniques is required to satisfy the critical need for sensitive and rapid detection of technetium-99 and strontium-90. Compared to current methods which require weeks, laser analysis can be completed in hours. This research addresses needs in both basic and applied research categories and will help determine the design parameters and evolution of field analytical platforms.

TECHNICAL APPROACH AND RISKS: Laser-based analysis techniques, primarily laser ablation mass spectroscopy (LAMS) and resonance-enhanced multiple photon ionization (REMPI), are proposed for chemical speciation of complex waste samples. Laser ablation can vaporize nearly any solid material in pulsed plumes of sufficient concentration for detailed analysis by mass spectrometry, laser-induced fluorescence (LIF), and other techniques. The LAMS approach couples laser vaporization with ultra sensitive mass spectrometry. Analysis of even complex, multi component mixtures can be performed rapidly and requires very little sample. This is highly desirable for the analysis of many environmental samples and hazardous wastes. When the concentrated laser ablation plumes are combined with multiphoton-ionization, time-of-flight mass spectroscopy, the result is a versatile and sensitive analysis technique of very high mass resolution which provides superb differentiation between compounds of similar masses and between isotopes. In addition, the resonant ionization process can provide excellent spectral resolution which extends and complements the mass resolution.

ACCOMPLISHMENTS: General and sensitive techniques were developed in FY 1996 to determine the molecular speciation of organics and inorganics that are present in tank wastes and chemisorbed on mineral soil substrates.

BENEFIT: These programs will increase our capabilities to analyze mixed waste. The results will be useful in performing the analysis of tank waste and crib wastes, and contaminated soils and ground water. The near-real-time analysis capabilities of these methods will also be important for monitoring waste retrieval, facilities decontamination, and other site restoration actions. It will contribute to the success of the DOE/Hanford Mobile Analytical Reconnaissance System (MARS) program which constitutes a major effort in meeting Hanford-site remote analytical and characterization needs for hot cells, and is predicted to result in a savings of $30-75 Million during the first three years following its implementation. Similar percentage savings can be expected at other DoD and DOE sites.

FY 1997 Milestones	Planned Date
1. Complete calibration of ablation yield of waste compounds, oxalic and citric acids, and sulfate	10/15/96
2. Complete analysis of waste simulant using negative ion detection	12/15/96
3. Determine ablation/ionization efficiency using femtosecond pulsed laser	02/15/97
4. Complete MALDI based microspraying analysis of inorganic phosphate, sulfate and oxalic acid waste compounds	04/15/97
5. Complete evaluation of laser ablation for contaminated soil analysis	08/15/97
6. Final report of the Laser Ablation/Ionization	09/15/97

PROJECT SUMMARY

PROJECT TITLE & ID: Kinetics of Supercritical Water Oxidation; CP-364

RESEARCH CATEGORY: 6.1 Basic Research

LEAD AGENCY: Department of Energy

LAB: Sandia National Laboratory - Lievermore, CA

PRINCIPAL INVESTIGATOR: Dr. Steven F. Rice

FY 1997 FUNDS: $500K

OBJECTIVE: Supercritical water oxidation (SCWO) is a technology under development by government laboratories, universities, and private industry for the treatment of aqueous wastes. However, the current understanding of the rates and mechanisms of reactions in supercritical water is limited to a handful of empirical rate expressions for very simple chemicals. These expressions are of limited use in the formulation of predictive models of SCWO for the design and operation of large-scale waste processing equipment. To be generally applicable as design tools, models must be based on elementary reaction steps or at least a detailed quantitative mechanistic description incorporating all the key fundamental reactions. This is a basic research project that will improve our ability to predict reaction rates in supercritical water. The project is designed to result in a user-friendly, computer-based model that will predict reaction rates and conversion efficiency for a wide range of waste feeds and reactor conditions.

TECHNICAL APPROACH AND RISKS: This work continues the experimental approach from earlier years. However, this is the final year of experimental data gathering to be incorporated into the overall model, now in the early stages of development. Earlier effort on this project has produce a good understanding of the reactivity of aliphatic C,H,O systems and has resulted in verified model predictions for the reactivity of feeds of this type, as single-component feeds. The FY 1996 work added the behavior of C,H,O aromatic species to this model. The behavior of chlorinated systems has been characterized as well. There are three important issues remaining to be resolved. First, the oxidative reactivity of nitrogen must be determined, as organic nitrogen such as in pyridine and urea, and as nitro groups that are found in many energetic materials. Experimental work on this task has been initiated in FY 1996 but will be a key aspect of the experimental work in FY 1997. Second, the method by which the model for pure feeds handles mixtures will need to be refined. It is certain that the reactivity of a fast reacting component will affect the reactivity of a more robust component. However, the extent to which this is important will need to be quantified. Finally, the behavior of polyaromatics will have to be explored to determine if there are special considerations for certain types of feeds that contain organic solids.

ACCOMPLISHMENTS: In FY 1996, a user-friendly computer-based supercritical water oxidation (SCWO) model was formulated that will predict reaction rates and conversion efficiency for a wide range of waste feeds and reactor conditions.

BENEFIT: SCWO is an emerging technology under development at several laboratories, including SNL, for the treatment of hazardous wastes such as obsolete chemical munitions, mixed wastes, and naval shipboard excess hazardous materials. The SCWO process, operating at two orders of magnitude greater density than atmospheric gaseous combustion, provides high reaction rates at moderate temperatures. The technical chemical engineering literature contains results of studies of SCWO measuring destruction efficiencies for a variety of waste chemicals and mixtures. Some of these data can be used to generate empirical, global kinetic rate expressions for a select list of simple species. However, the in-situ measurements used in this project, particularly on intermediates, will lead to valuable information for predictive model development. This better understanding of reaction rates and the kinetic models this project is developing, have already produced advanced strategies for reactor design and improved methods for commercial system optimization. This technology is developing rapidly. In addition to presentations at technical meetings and publication in the reviewed literature, results from this project are made available to the SCWO technical community through detailed quarterly reports sent to a wide distribution.

FY 1997 Milestones	Planned Date
1. Complete N_2O => N_2 measurements, publish	03/01/97
2. Initiate R-NO_2 oxidation/pyrolysis measurements	03/01/97
3. Place 3rd year of contract with MIT	04/01/97
4. Complete mixture reactivity measurements (MIT)	06/01/97
5. Release C,H,O reactivity code to public	10/01/97
6. Complete R-NO_2 => N_2, CO_2, H_2O model	12/01/97

PROJECT SUMMARY

PROJECT TITLE & ID: Lead-Based Paint Hazard Mitigation; CP-521

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: U.S. Army

LAB: Construction Engineering Research Laboratory - Champaign, IL

PRINCIPAL INVESTIGATOR: Dr. Ashok Kumar

FY 1997 FUNDS: $600K

OBJECTIVE: The technical objective of this project is (a) to develop and demonstrate novel vitrification technology using thermal spray or microwave energy for lead-based paint removal and disposal that can be used effectively for immobilization of heavy metal hazardous waste and (b) to evaluate emerging technologies for lead-based paint abatement including in-place management, sponge blasting, environmentally friendly chemical strippers, and cryogenic blasting. Currently used abatement technologies result in the emission of hazardous lead dusts as well as hazardous waste. Environmental contamination by fugitive dust emissions is regulated under the Clean Air and Water Acts while the Resource Conservation and Recovery Act (RCRA) addresses the proper disposal of lead-bearing wastes.

TECHNICAL APPROACH AND RISKS: The technical approach for objective (a) involves the preparation of vitrified materials and determining through characterization techniques how the hazardous waste is incorporated within the glass structure and immobilized. The mechanisms of vitrification and ion-leaching processes will be modeled to optimize hazardous waste immobilization. This model will be used to engineer durable, designer glass compositions for vitrification of lead-based paint. The application processes involve using thermal spray or microwaves for brick, masonry, concrete and wooden structures. The approach for objective (b) is to evaluate the efficacy and cost-effectivenss of emerging technologies for in-place management and removal of lead-based paint including cryogenic blasting, environmentally friendly chemical strippers, sponge blasting and laser stripping. A decision tree will be developed to select the optimum technology for lead-based paint hazard mitigation based on a paint condition index.

ACCOMPLISHMENTS: The synergistic combination of microwaves and chemical strippers is being evaluated for hard painted surfaces. In FY 1996 a microwave applicator was fabricated and tested in the laboratory for paint removal efficiency on painted wood specimens, using graphite as the microwave enhancer. The heat generated by graphite interacting with the microwaves softened the paint which was easily removed in about two passes.

BENEFIT: The research and development of lead-based paint abatement technologies will reduce the cost of lead-based paint hazard mitigation which is estimated to exceed $1 billion for DoD installations. The most significant benefit of this work is the optimized management of lead-based paint hazards and the increased protection of the health of DoD personnel and their families. Enhanced quality of life for the soldiers and their families leads to increased troop retention and a more capable force.

FY 1997 Milestones	Planned Date
1. Complete test of paint removal efficiency in field	06/01/97
2. Complete microwave leak testing in field	07/01/97
3. Complete field test of microwave applicator	09/01/97
4. Complete decision tree for lead management	09/01/97

PROJECT SUMMARY

PROJECT TITLE & ID: Controlling, Assessing, Managing, and Monitoring the Noise Impacts from Weapons, Helicopters, and Aircraft on Training and Readiness; CP-523

RESEARCH CATEGORY: 6.1 Basic Research

LEAD AGENCY: U.S. Army

LAB: Construction Engineering Research Laboratory - Champaign, IL

PRINCIPAL INVESTIGATOR: Dr. Paul Schomer

FY 1996 COMPLETED PROJECT

OBJECTIVE: Preservation of the Department of Defense (DoD) training, testing and readiness mission requires that DoD be capable of controlling assessing, managing and monitoring noise problems in the vicinity of its bases and installations. As a result of noise impacts, the DoD has lost significant mission capability at over 50 installations. The ojective of this research is to provide more technically and legally defensible analyses of the effects of noise from DoD operations.

ACCOMPLISHMENTS: This project developed the combined noise model, which is a dose-response empirical model that provides the means for DoD to assess and mitigate noise. The model was developed in three phases: (1) initial combined effects model was developed based on the current state-of-the-art and through consensus with the American National Standards Institute (ANSI); (2) results of other, related research by the Army, Air Force and NASA and international partners were used to revise the initial model; (3) validated of combined noise effects model in a series of field tests. Measurements on both structural and human responses were completed in FY 1996.

BENEFIT: The results of this research and development program will significantly contribute to protecting the operational capability of military installations to perform their readiness mission while minimizing noise impacts. This more robust and improved understanding of the issues will manifest itself as increased public acceptance of AICUZ/ICUZ studies and the noise portions of environmental impact analysis documents (EAs, EISs) for future DoD operations.

TRANSITION: A report on blast/sonic boom effect studies and an American National Standard Method for combined effects will be issued.

PROJECT SUMMARY

PROJECT TITLE & ID: Evaluation of the Use of Waste Energetics as Supplemental Fuels; CP-524

RESEARCH CATEGORY: 6.3 Advanced Development

LEAD AGENCY: U.S. Navy

LAB: Naval Surface Warfare Center - Indian Head, MD

PRINCIPAL INVESTIGATOR: Mr. Tim Dunn

FY 1997 FUNDS: $300K

OBJECTIVE: The objective of this project is to develop technology for using waste energetic materials to supplement fuel oil in the feed to a steam-generating boiler. This technology recovers the energy content of the energetic material and provides an alternative to open burning/open detonation (OB/OD).

TECHNICAL APPROACH AND RISKS: The technical approach is based on continuing work from previous tests. Mixtures of various energetics will be burned with fuel oil in a boiler. Emissions data will be collected in order to develop models for scale-up. Much of the work will involve fuel preparation and transfer. Settling and plugging are expected problems that will have to be overcome. Risks are minimized because long lead-time items such as the Continuous Emissions Monitoring System (CEMS) installation, Director of Defense Explosives Safety Board (DDESB) site approval, and the primary technical review have been completed. There is a small to moderate risk that delivery and installation of the new slurry tank and its use with the homogenizer may cause delays.

ACCOMPLISHMENTS: A demonstration system to test the fuel nozzle and atomizer was successfully fired with Number 2 fuel oil in FY 1996. The continuous emissions monitoring system (CEMS) was certified and installation is near completion. A preliminary review verified that the overall system provides results that are sufficiently accurate and repeatable, according to EPA guidelines. Lab scale energetics grinding and melting studies have been completed, demonstrating that energetic materials can be safely and effectively reduced in size. Tests for chemical compatibility of the energetic fuel oil mixtures indicate that all of the mixtures accept the TNT/Fuel Oil mixture are considered compatible. The TNT/Fuel oil mixture showed a slight incompatibility and will be investigated further.

BENEFIT: The successful demonstration of this technology will provide evidence to support industrial scale trials. Industrial use of excess energetics will alleviate DoD stockpiles and make use of the materials' heat content which is wasted by other methods. Furthermore, States are expected to limit permits for the alternative, OB/OD. Finally, this technology

allows for the controlled discharge of exhaust emissions, which cannot realistically be done with OB/OD.

FY 1997 Milestones	Planned Date
1. Arrival of funds	10/29/96
2. Otto Fuel Test	11/01/96
3. Nitroguanidine (NG) Test	12/01/96
4. Nitrocellulose (NC) Test	02/01/97
5. Propellant Test	03/01/97
6. Homogenizer Installation and Review	08/01/97
7. Homogenizer Propellant Test	08/01/97
8. Homogenizer Composition B Test	08/01/97
9. Report Submission	09/01/97

PROJECT SUMMARY

PROJECT TITLE & ID: Demonstration of Compact, Closed Loop Controlled Waste Incinerator; CP-887

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: U.S. Navy

LAB: Naval Air Warfare Center - China Lake, CA

PRINCIPAL INVESTIGATOR: Dr. Klaus Schadow

FY 1997 FUNDS: $600K

OBJECTIVE: The objective of this project is to apply the technical basis of new Compact, Closed-Loop Controlled Waste Incinerator technology developed in project **CP-034** to two specific Navy incinerator programs: (1) development of a compact and efficient afterburner for a plasma arc thermal destruction system; and (2) a sludge incinerator for black water destruction.

TECHNICAL APPROACH AND RISKS: The plasma arc system will be explored for ship-board waste management under an Advanced Technology Demonstration (ATD) program which starts in FY 1997. The black water incinerator, which is being used on different classes of Navy ships, is presently being up-graded under NAVSEA funding. The SERDP technology will be used to increase the through-put and extend the waste stream from black water to concentrated sludge derived from black and gray water, and also from oily wastes using new SERDP-developed membrane technology.

A two phase demonstration program will be undertaken. In the first phase, two Process Development Unit (PDU) demonstrations will be carried out. Existing equipment will be modified and existing control components will be used. In the second phase, a demonstration of optimized systems will be conducted with the advanced control components and enhanced physical understanding which is being developed under project **CP-034**.

The afterburner PDU demonstration will be primarily based on recent SERDP scale-up experiments using controlled vortex combustion with standard actuators and sensors, a simple time-delay controller, and open-loop control. Cold pyrolysis gases initially will be used. The sludge incinerator PDU demonstration will be based on recent EPA supported experiments using resonant acoustics for increased solid waste pyrolysis.

For the demonstration of the optimized afterburner, critical features of the trapped vortex concept will be integrated into the actively controlled concept. The design will be modified for the use of realistic (hot) pyrolysis gases. Subsequently, advanced sensors and actuators,

and an adaptive controller for closed-loop control will be used. The performance of the new, compact, actively controlled incinerator will be compared with alternative disposal options (both current and other possible technologies). For the optimized sludge incinerator, a design based on the emerging S&T results will be developed and tested.

ACCOMPLISHMENTS: A test program to evaluate the performance of the controlled afterburner at 300kW is nearly complete. This program is providing emissions data that are being compared with results generated by NAWC on a smaller scale (5 and 50kW) to ensure that the full potential of performance improvements are achieved at the 300kW scale.

BENEFIT: Successful shipboard demonstration of a compact incinerator with real-time exhaust monitoring for active combustion control represents a significant step towards assured waste incineration and can be the basis for the next generation incinerators. The compact-incinerator technology will be essential for the development of environmentally sound ships beyond the year 2000. Compact incinerators are also desirable for on-shore use in the government and private sector. Small, compact incinerators will allow on-site waste destruction and avoid waste transportation to large incineration sites. In particular, medical waste incineration is a prime candidate in the private sector for a compact system. The closed-loop active control of the incineration process will for the first time assure proper incineration during design and off-design operation. Successful demonstration of the assured waste incineration on-board ships will result in significant cost savings by avoiding cost for waste off-loading and on-shore destruction, particularly in foreign countries.

FY 1997 Milestones	Planned Date
1. Trapped Vortex Afterburner Tests Completed (50KW	11/30/96
2. Afterburner Tests with Hot Gas Simulation Completed (50KW)	01/31/97
3. Test Report on 1MW PDU Afterburner (Cold Gases) Complete	01/31/97
4. Test Report on PDU Sludge Incinerator Completed	03/31/97
5. Test Report on 1MW Optimized Afterburner (Hot Gases) Complete	07/31/97
6. Testing of Optimized Sludge Incinerator Initiated	11/30/97
7. Controller for Optimized Afterburner Defined Characterization of Solids Program	11/30/97

PROJECT SUMMARY

PROJECT TITLE & ID: Development of Non-Thermal Plasma Reactor Technology for Control of Atmospheric Emissions; CP-1038

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: Department of Energy

LAB: Los Alamos National Laboratory - Los Alamos, NM

PRINCIPAL INVESTIGATOR: Dr. Louis Rosocha

FY 1997 FUNDS: $525K

OBJECTIVE: The overall project objective is to evaluate and develop new non-thermal plasma (NTP) reactor technology for DoD air emissions control applications. A key goal is to provide a basis for selecting the most appropriate NTP technology for DoD application by evaluating the performance of prototype and pilot-scale NTP reactors (i.e., corona, dielectric barrier, and electron beam) for NOx and HAP abatement and specialized VOC control and to assist in the commercialization of the technology. The development of an efficient, reductive-model NOx processor is a key goal.

TECHNICAL APPROACH AND RISKS: In the first year a comparative assessment of electric-discharge driven and electron-beam driven NTP reactors will be performed, reaction kinetic models and predictive, reactor simulation model will be developed. In the second year reactor scaling criteria and optimization models will be developed and scaling studies will be initiated with laboratory-pilot apparatus. In the third year, reactor scale-up, optimization, and system engineering will be completed to the point of starting the design of a field-pilot unit. The fourth year will concentrate on constructing and testing a field-pilot unit at a selected DoD site and providing criteria for selecting the most appropriate NTP technology for DoD applications. A cost-benefit assessment for NTP technology application to NOx and VOCs will be addressed as part of this project.

The comparative assessment work will build upon a 1995 NIST workshop on NTP applications to air pollution control. NIST will also assist in plasma chemistry model development and laboratory measurements of reaction-chemistry relevant parameters. Reactor performance measurements will be carried out using GC/MS (gas chromatography/mass spectrometry), TDL (tunable diode laser) and LIF (laser induced fluorescence) probes, with ARL taking the lead on optical/laser measurements. ARL will also carry out CFD (computational fluid dynamics) calculations to predict and optimize fluid flow patterns and treatment residence times. Los Alamos will focus on electric discharge physics, electrical drive circuit engineering and optimization, and the design and construction of laboratory test, pilot, and scaled-up reactors.

NTP technology is frequently an energy-intensive process that sometimes produces undesirable byproducts. The risk is being able to minimize these byproducts while reducing the energy consumption. Electron-beam NTP technology is further hampered by the availability and life of vacuum-separator windows and attendant energy losses in these foils from low-energy electrons.

ACCOMPLISHMENTS: Building on a National Institute for Standards and Technology (NIST) workshop on NTP applications to air pollution control, a comparative cost-benefit assessment of electric-discharge driven and electron-beam driven NTP reactors was performed in FY 1996, and a Technology White Paper was submitted to the SERDP Program Office. Plasma chemistry reaction kinetic models were developed for a predictive, reactor simulation for use in prototype development and scale-up, and optical/laser-based plasma diagnostics were designed. Baseline designs for two laboratory prototype NTP reactors (pulsed corona and dielectric barrier) were completed.

BENEFIT: All organizations (DoD, DOE, industry) affected by the need to control emissions of NOx and HAPs/VOCs will benefit from the development of a flexible technology for emissions control and a basis of selecting the most appropriate technology for specific needs. With the successful development and implementation of NTP technology, present and planned missions can proceed without deleterious environmental impacts or major compliance-issue and cost escalations. Particular technical impacts are an increase in the efficiency of electric-discharge NTP (by control of discharge physics and plasma chemistry) and the potential for development of low back-pressure, filterless, scrubberless NOx control equipment using reductive mode processing (i.e. go to N_2 and O_2 terminal products), effected by improved electrical driver technology. Also, other VOC-abatement technologies are not yet fully proven, so NTP can be a promising back-up in some cases.

FY 1997 Milestones	Planned Date
1. Construct lab-scale prototype NTP reactors	11/30/96
2. First report on reactor performance and benchmarking measurements	01/10/97
3. First report on scaling criteria and algorithms/models for reactor optimization	07/31/97
4. Feasibility analysis report for hybrid NTP reactors	09/30/97

PROJECT SUMMARY

PROJECT TITLE & ID: Development and Integration of Laser-Based Sensors for VOC/NOx and Metals Emissions Monitoring; CP-1060

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: Department of Energy

LAB: Sandia National Laboratory - Livermore, CA

PRINCIPAL INVESTIGATOR: Dr. Scott Bisson

FY 1997 FUNDS: $600K

OBJECTIVE: The objective of this project is to develop a combined laser-based system for monitoring VOC/NOx and metals for compliance with the Clean Air Act Amendments of 1990. For gaseous pollutants, an infrared (IR) spectrometer based on the new, periodically-poled, lithium niobate (PPLN) laser technology will be used. For metals emissions monitoring, the technique of laser induced breakdown spectroscopy (LIBS) will be employed.

TECHNICAL APPROACH AND RISKS: For development of the IR Spectrometer, the tunability, spectral bandwidth, and oscillation threshold of the PPLN source will be characterized. Given the wide range of species to be detected and the fact that the absorption spectra span the infrared, broad tunability will be essential. Reduction of the oscillation threshold will be attempted. The detection sensitivity will also be optimized through the use of acoustically resonant cells.

For development of the portable LIBS, currently available solid-state diode lasers will be identified and evaluated for long-term operation. The feasibility of using a solid-state laser for plasma ignition and spark generation will be investigated. If successful, this would reduce the physical dimension and weight of the LIBS system substantially and move one step closer to the portable unit proposed. Other compact lasers such as a diode-pumped Nd:YAG laser will also be evaluated. A thumbnail-sized microspectrometer will be employed for the portable LIBS system (patent-pending).

For actual hardware integration, the goal is to exploit commonality between the IR spectrometer and the LIBS instrument to the extent possible but without sacrificing performance. Three areas of instrumental commonality between the two components have been identified. These are the laser source, the sample interaction region, and the operating software. During the course of the integration phase, the feasibility of sharing these components in the integrated system will be determined. A common laser must serve the dual purpose as a pump source for the PPLN laser and a spark source for the LIBS

measurement. The final sensor systems will be packaged for specific industrial or environmental applications and marketed by commercial partners.

BENEFIT: If successful, this technology would allow, for the first time, near real time, in-situ analysis for monitoring a wide range of species (metals and gases) with higher sensitivity than previously achievable. There are also potential applications in process control and atmospheric chemistry research. Moreover, the compact size of this new system is attractive and its cost is anticipated to be competitive with many conventional, laboratory analytical services.

FY 1997 Milestones	Planned Date
1. Identify and evaluate laser sources suitable for portable LIBS	02/01/97
2. Develop electronic and optical components for the portable LIBS	04/01/97
3. Design and fabricate laser excitation sample cells and aerosol generation control	05/01/97
4. Couple laser, spectrophotometer, sampling cell into complete LIBS (initially using lenses & mirrors then using fiber optic cable coupling)	08/01/97
5. Incorporate computer control capabilities	08/01/97
6. Perform spectroscopic measurements, calibration and construct a digital spectral library	08/01/97
7. Examine detection limits for selected metals; determine pule length and spectrophotometer gating time	09/01/97
8. Sensitivity analysis on selected matrices	09/01/97
9. Develop acoustically resonant cell (IR)	05/01/97
10. Measure oscillation threshold and spectral properties (IR)	07/01/97
11. Conduct wavelength tuning experiments (IR)	10/01/97
12. Conduct photoacoustic and wavelength modulation spectroscopy experiments (IR)	10/01/97
13. Establish P2 user advisory group	04/01/97

PROJECT SUMMARY

PROJECT TITLE & ID: Detect and Identify Multiple Hazardous Air Pollutants (HAPs) at Extended Distances; CP-1061

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: U.S. Navy

LAB: Naval Research Laboratory - Washington, D.C.

PRINCIPAL INVESTIGATOR: Dr. Phillip Sprangle

FY 1997 FUNDS: $250K

OBJECTIVE: The objective of this project is to develop a new class of active remote sensing sources and techniques for the detection and identification of hazardous air pollutants (HAPs). Active remote sensing with ultra broadband (UB) radiation can provide real-time ranging and identification of HAPs at extended distances.

TECHNICAL APPROACH AND RISKS: Ultra broadband (UB) radiation can be generated in a nonlinear optical medium with picosecond laser pulses. The mechanism for the generation of UB radiation is based on self-phase modulation in nonlinear medium. Continuous UB radiation can be generated with extremely high efficiency and high average power by beating two laser beams with slightly different frequencies in a nonlinear medium. The bandwidth of the radiation can extend from the optical to the Infrared (IR) regime. UB radiation can provide the necessary illumination required for active remote sensing. The source size of the UB radiation is extremely small, which allows for beaming the radiation over extended distances of several kilometers.

The generation of UB radiation in various nonlinear material will be analyzed and evaluated using existing laser facilities at the Naval Research Laboratory (NRL). Lasers with optical and near IR wavelengths will be used to generate UB. The conversion efficiency and bandwidth will be optimized by selecting the appropriate nonlinear medium. The quality of the UB radiation beam will be measured, and its propagation in air characterized. The methodology and diagnostics necessary to evaluate the UB spectrum are based on hyperspectral imaging techniques that are presently being developed at NRL. Proof-of-principle experiments on active remote sensing will be performed. Data reduction techniques for analyzing complex spectral signatures will be studied.

BENEFIT: The application of UB radiation sources to remote sensing can lead to the identification, ranging, and detection of HAPs at extended distances through simultaneous spectral response from various HAPs. It will allow the tracking of major HAPs such as nitrogen oxides (NO_x) and others (ClO_x, SO_x). It is also especially valuable during night time

monitoring when sunlight is not available for conventional remote sensing methods. A system of active remote sensing using UB radiation will benefit efforts on continuous real-time identification of HAPs that are of concern to DoD.

FY 1997 Milestones		Planned Date
1.	Initiate beat wave generation using two lasers with different frequencies	10/01/96
2.	Complete beat wave generation	12/31/96
3.	Initiate UB generation from beat wave in nonlinear medium	01/01/97
4.	Initiate characterization of UB radiation	01/01/97
5.	Complete UB generation in nonlinear medium	02/28/97
6.	Initiate optimization of UB radiation	03/01/97
7.	Initiate characterization of detector	03/01/97
8.	Initiate modeling of multi wavelength DIAL	03/01/97
9.	Complete characterization of UB radiation	05/30/97
10.	Initiate design of laboratory experiment to identify known HAP simulant with UB radiation	06/01/97
11.	Complete optimization of UB radiation	09/30/97
12.	Complete characterization of detector	09/30/97
13.	Complete modeling of multi wavelength DIAL	09/30/97
14.	Complete design of laboratory experiment to identify known HAP simulant with UB radiation	09/30/97

APPENDIX C
Conservation Project Summaries

PROJECT SUMMARY

PROJECT TITLE & ID: Whale Monitoring Using IUSS; CS-48

RESEARCH CATEGORY: 6.3 Advanced Development

LEAD AGENCY: U.S. Navy

LAB: Office of Naval Research - Arlington, VA

PRINCIPAL INVESTIGATOR: Dr. Robert C. Gisiner

FY 1997 FUNDS: $1,790K

OBJECTIVE: To continue applying U.S. Navy Integrated Undersea Surveillance System (IUSS) capabilities to monitor various species of living resources, and to contribute to the conservation and regulatory compliance goals of the U.S. Navy. The IUSS provides a unique resource to monitor the presence, distribution, movements, and relative abundance of several endangered and protected marine mammal stocks, with greatest emphasis on the large baleen whales. A close working relationship has been developed with NOAA, and will continue to be an essential goal of the project in consideration of NOAA's role as the management and regulatory agency for protected marine life. This project will also work on the resolution of security issues concerning the IUSS database with the goal of developing accessible databases for unclassified use in education, research, and database management. Research efforts involving IUSS will also be coordinated with Navy environmental compliance efforts to enhance the Navy's leadership role in developing the highest compliance and monitoring standards for assessing and mitigating the effects of manmade noise on the marine environment.

TECHNICAL APPROACH AND RISKS: Emphasis will be focused on three primary tasks: 1) integration of IUSS data into Navy/NOAA databases used in assessing potential impacts of human activities on endangered and protected marine mammals, 2) creation of unclassified IUSS data access for use in education, research, resource management databases (e.g. GIS), and 3) comparative assessment of IUSS capabilities with other marine mammal monitoring and assessment tools. The first task will be approached by continuing ongoing data collection programs for both the North Atlantic and Northeast Pacific IUSS assets. The data from these efforts will be transitioned to coordinated, collaborative efforts by the Navy and by NOAA to establish centralized marine mammal databases for use in stock management (NOAA) and risk assessment decisions for environmental compliance actions (Navy and NOAA). The second task will employ declassified single hydrophone data from four deactivated arrays in the Pacific, managed by Navy activities (Naval Postgraduate School, NRaD), and employ a reactivation of the Bermuda arrays by a consortium of SERDP, nonprofit environmental organizations, and industry. The third task will be accomplished through the coordinated monitoring of IUSS data in conjunction with official NOAA marine

mammal surveys, and university researchers. The independent data sets obtained by each researcher will be compared with IUSS data to develop probability of detection values, and relative effectiveness assessments for all of the survey methods involved. Risk factors include (1) the potential loss of IUSS assets through Navy downsizing of the system and through natural events such as underwater landslides that can damage the system, and (2) the possibility of compromising IUSS security through the release of inappropriate data.

ACCOMPLISHMENTS: "WHALES 95" was the first attempted intercomparison between visual and acoustic observations of whales. "Northeast Pacific 95" was a NOAA-led effort to determine signal characteristics of great whales at a number of different spatial scales, ranging from near-vessel sonobuoy records to distant IUSS stations. Additionally, beginning in FY 1996, the project has initiated efforts to reactivate the Bermuda IUSS Array in order to help perfect triangulation capabilities for whale monitoring in the mid-Atlantic Ocean. The Bermuda facility was closed in November of 1994, taking away a vital component of the IUSS in the western North Atlantic. With leveraged funding from the private sector, re-opening the Bermuda facility will make data available for a range of dual-use purposes, especially whale research and monitoring.

BENEFIT: The research will enhance the U.S. Navy's ability to assess and mitigate potential impacts of its activities on marine mammals. Without the data supplied by IUSS, critical Navy activities are at serious risk of being limited due to uncertainty about the potential for environmental impact. The project greatly improves NOAA's ability to carry out its mission of conserving and managing marine mammal stocks by greatly expanding the database on little-known, wide ranging, pelagic, marine mammals like the large whales. This project will also help calibrate the survey methods currently used by NOAA to estimate marine mammals stocks.

FY 1997 Milestones	Planned Date
1. Develop Unclassified Data Sets	01/01/97
2. Integrate IUSS Long Term Monitor with Navy/NOAA databases	01/01/97
3. Final Report on Humpback Whale Monitoring in the NE Pacific	03/01/97
4. Complete Report on LFA Sonar Effects	06/01/97
5. Conduct Joint NOAA/IUSS Calibration Surveys	07/01/97
6. Initiate North Sea Airgun Effects Monitoring	08/01/97
7. Call Density Maps, Atlantic and Pacific	10/01/97
8. Interim Report to SERDP	11/01/97

PROJECT SUMMARY

PROJECT TITLE & ID: The Effects of Aircraft Overflights on Birds of Prey; CS-89

RESEARCH CATEGORY: 6.3 Advanced Development

LEAD AGENCY: U.S. Air Force

LAB: Armstrong Laboratory - Wright Patterson Air Force Base, OH

PRINCIPAL INVESTIGATOR: Captain Michael Carter

FY 1997 FUNDS: $330K

OBJECTIVE: The public continues to raise concern over the possible effects of noise resulting from military low-altitude aircraft. Even though some research has been accomplished in this technical area, conclusive results have not been documented for many types of animals. The Air Force has developed, through meta-analysis, an interim dose-response model to predict the effects of aircraft noise on raptors (birds of prey), but this model has not been fully tested. This research examines the problem and tests the Air Force model. This advanced technology research (6.3A) will be inserted into the latest version of the Assessment System for Aircraft Noise (ASAN) model for Air Force and DoD-wide use in environmental impact analyses.

TECHNICAL APPROACH AND RISKS: The first task developed a study protocol in cooperation with the National Biological Service, University of Alaska Fairbanks Cooperative Fish and Wildlife Research Unit. The protocol addressed the effects of military aircraft overflights on raptor populations and included such factors as habitation, prey abundance and changes in parental behavior. Task 2 is designed to make observations of behaviors and responses of nesting raptors during aircraft overflights. Task 3 attempts to address the effects of aircraft overflight noise on threatened and endangered species such as Peregrine Falcons and Bald Eagles. Tasks 2 and 3 are being performed within this project. The last task (Task 4) will involve making alterations to the current dose-response model for Air Force use and inserting the model into the latest version of ASAN in FY 1998.

The 11th AF is providing aircraft support -- a critical element of this project for both the quality and quantity of the overflights. In the first two field seasons, we lost a number of potential overflights due to real-world deployments and changes in training schedules We will work to ensure Air Staff-level support of this project for its final field season. The field crews also risk some down time due to problems on the Tanana River, which has been very treacherous and damaging to the boats. These problems are not entirely under our control and may hamper our efforts in the final field season.

ACCOMPLISHMENTS: The project has developed a defense-unique Animal Noise Monitor (ANM) for noise data collection to accurately assess noise exposure levels. In FY 1996, the second field data collection season was completed successfully. Approximately forty ANMs were deployed at experimental and control sites to gather quantitative noise data on the overflights. The field teams made routine behavioral observations at both experimental and control sites, and recorded behavioral observations of the birds to jet aircraft overflights. The effort benefitted from some of the best "worst-case" scenarios on a limited number of occasions, thanks to the cooperation of Air Force forward air controllers calling jet aircraft directly over specific nests.

BENEFIT: In furthering our understanding of the effects of military aircraft overflights on the environment, this project will: 1) enhance our management tools for monitoring effects, 2) obtain valuable baseline data not previously obtained (past information is anecdotal in nature) and 3) improve our capability to predict noise effects on raptors. We developed a defense-unique Animal Noise Monitor for remote noise data collection to accurately asses noise exposure levels. We also developed an interim dose-response model for raptors that will be validated or updated, depending upon the results of this effort. We will incorporate this updated model into ASAN, which will greatly assist environmental planners in conducting environmental impact analyses, developing timely environmental planning documents, and addressing concerns raised by the general public. These integrated resource management techniques will minimize potential noise impacts of aircraft operations on threatened and endangered raptors while maintaining mission readiness.

FY 1997 Milestones	Planned Date
1. Evaluate/Update Field Data Collection Methods	02/01/97
2. Obtain All Field Equipment/Supplies	05/01/97
3. Identify All Nest Sites to be Observed/Monitored for Productivity	06/01/97
4. Complete Test Flights	08/01/97
5. Complete Observations/Monitoring of Experimental and Control Test Sites	09/01/97
6. Determine Fledgling and Final Productivity Rates	10/01/97
7. Make Alterations to the Current Dose-Response Model if Necessary	10/01/97
8. Final Report	10/01/97

PROJECT SUMMARY

PROJECT TITLE & ID: Ecological Biomarkers: Monitoring Wildlife Fauna at DoD Installations; CS-244

RESEARCH CATEGORY: 6.4 Demonstration and Validation

LEAD AGENCY: Environmental Protection Agency

LAB: National Exposure Research Laboratory - Cincinnati, OH

PRINCIPAL INVESTIGATOR: Dr. Bernie Daniel

FY 1997 FUNDS: $150K

OBJECTIVE: The project goal is (1) to apply biomarkers (physiological, biochemical and molecular changes in aquatic and terrestrial organisms), as tools to assess and monitor impacts of defense-associated chemical production and application, (e.g. munitions manufacturing, open detonation and open burning, decommissioning and de-arming chemical agents, fuel refining and storage, machine de-greasing wastes, and chemical by-products) on sensitive aquatic and terrestrial fauna at selected DoD facilities; (2) to establish patterns of biomarkers changes, via comparative studies of native fauna in contaminated and reference sites, that are useful for demonstrating the existence or non-existence of ecosystem level impacts from these materials, and (3) to determine which biomarkers appear to be predictive of decrements in the status of the ecological resources.

TECHNICAL APPROACH AND RISKS: Site selection will be focused on those munitions-contaminated installation(s) located in strategic proximity to ecologically appropriate reference site(s). The contaminated and reference sites will be inventoried and the ecological assets elucidated and suitable measurement endpoints will be selected on the basis of the biomarker methods available and on the ecological resources to be monitored. Assessments of exposure and effects from munitions compounds and by-products. The biomarker profiles of selected wildlife will be compared in the contaminated and impacted sites and referenced against the status of the ecological assets. Biomarkers that appear predictive of ecosystem impacts will be identified for future assessments at other DoD facilities. Laboratory studies focusing on selected munitions compounds and their products (e.g., trinitrotoluene, trinitrobenzene, dinitrobenzene, tetryl and other contaminants of ecological concern (e.g., polycyclic aromatic hydrocarbons, or heavy metals) will support the verification of field results. Repeated measurements over time and across diverse landscapes will strengthen our ability to detect meaningful (statistically significant) difference among populations within a study series.

ACCOMPLISHMENTS: In FY 1996, this project developed biomakers to quantify exposures to nitroaromatic munitions compounds and their by-products -- such as 2,4,6-trinitrotoluene

(TNT), 1,3,5-trinitrobenzene (TNB), 1,3-dinitrobenzene (DNB), and tetryl (TET) -- which are the frequent explosives contaminants at DoD facilities. For the first time, research toxicity results on TNB demonstrated that the currently acceptable cleanup level for TNB of 0.96 ppm may be raised as much as 600-fold because TNB appears less hazardous than was previously calculated using extrapolated numbers from other similar chemicals. Hence, a smaller number of TNB contaminated sites might require cleanup, and those remediated might not need to be cleaned up as thoroughly as previously required. This new standard should result in considerable cost savings, perhaps 50 percent or more. This new technology has been evaluated in a field study at the SERDP NETTS demonstration site at Volunteer Army Ammunition Plant (VAAP), Chattanooga, TN, in collaboration with the scientists from the U.S. Army Center for Health Promotion and Preventive Medicine (CHPPM), Aberdeen Proving Ground, MD.

BENEFIT: The proposed project will benefit the DoD (and the public) by: 1) providing baseline data to assess the ecological impact of munitions activities; and 2) providing a quantitative means to document the ecological state of the impacted area and to prove or disprove cause-effect relationships between munitions by-products contamination and ecological effects.

	FY 1997 Milestones	Planned Date
1.	Develop Expanded List of Sampling Sites -- Volunteer Army Ammunition Plant (VAAP)	10/01/96
2.	Complete All Extramural Funding Packages	11/01/96
3.	Complete Revised Field Sampling and Safety Plans	02/01/97
4.	Finalize All Biomarker Methods for Repeat Study	04/01/97
5.	Initiate Expanded Study at VAAP (or Alternate Site)	06/01/97
6.	Complete Data Analysis of New Field Samples	12/01/97
7.	Prepare Final Report	03/01/98

PROJECT SUMMARY

PROJECT TITLE & ID: Genetic Diversity Monitoring in Plants and Wildlife; CS-246

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: Environmental Protection Agency

LAB: National Exposure Research Laboratory - Cincinnati, OH

PRINCIPAL INVESTIGATOR: Dr. Gregory Toth

FY 1997 FUNDS: $110K

OBJECTIVE: The aim of this project is to use DNA fingerprint techniques as genetic diversity measures for aquatic population, primarily fish, and terrestrial populations of both animals and plants which inhabit contaminated and/or ecologically sensitive areas impacted by military installation and activities. The genetic diversity or gene repertoire of a population reflects its intrinsic robustness. Loss of genetic diversity leaves a species less able to adapt to new stressors and therefore, loss of population genetic diversity can foreshadow species loss, with resultant loss of biological diversity within the community. Loss of diversity resulting from habitat destruction and pollution is a major concern in wildlife populations.

TECHNICAL APPROACH AND RISKS: We are applying several fingerprinting methods to population analysis. The first is the VNTR method which is based on Southern blots. The second fingerprinting method is a PCR (polymerase chain reaction) based technique. In this method, bands are produced by preferential amplification of segments of DNA that happen to be bracketed by sequences complementary to the synthetic DNA oligomers used as primers in the reaction. This is termed the DAF or DNA amplification fingerprint. Additional methods are under development, including use of mini-satellite DNA probes. These methods have been applied to test samples of DNAs purified from more than seventy individual brown bullhead catfish representing three populations from both polluted and clean areas. Preliminary data are supportive of our hypothesis, namely that fish from the most polluted aquatic environment are more genetically homogeneous than those from a cleaner environment. Using the raw fingerprint data from these methods, several mathematical treatments for assessing DNA fingerprint diversity are being examined and compared in order to determine the best statistically valid approach. We are also using the VNTR method to examine genetic variation in the common cattail, Typha latifolia, and the swamp dewberry, Rubus hispidus. Leaves were collected from four areas along two inter-connected beaver ponds located on the Wurtsmith AFB in MI. We have collected amphibians and bullhead catfish from the same contaminated and uncontaminated beaver ponds and continue to examine our hypothesis with these populations using the DAF method.

ACCOMPLISHMENTS: Quantitative measures of population genetic diversity can serve as an assessment tool to identify vulnerable populations and sub-populations of many species of animals and plants, and to monitor their responses to ongoing conservation and protection efforts. In FY 1996, the project continued genetic diversity analyses of fish and plants from several sites at Wurtsmith Air Force and refined statistical evaluation of DNA fingerprints and modification of genetic diversity databases for application to GIS. This work will allow future investigators to examine correlations of genetic diversity with other indicators over geographic scales using relational databases.

BENEFIT: The project will benefit the military ecological resource managers (and the public) by: 1) providing baseline data to assess the ecological impact of military activities; and 2) providing a quantitative means to document the ecological state of the impacted area and to prove or disprove cause-effect relationships between munitions by-products contamination due to military activities and ecological effects.

FY 1997 Milestones		Planned Date
1.	Complete Report on Quality Assurance Issues in DNA Fingerprinting - PCR Optimization for Detection of Polymorphisms	01/01/97
2.	Complete Report on Quality Assurance Issues in DNA Fingerprinting - Fingerprint Analysis with Computerized Fluorescence Imaging Systems	02/01/97
3.	Complete Analysis of Fish and Plant Specimens from August 96 Field Trip to Wurtsmith Air Force Base (WAFB)	03/01/97
4.	Science Journal Article on Genetic Diversity in a Selected Species of Fish at WAFB	09/30/97
5.	Science Journal Article on Genetic Diversity in Selected Plant Species at WAFB	09/30/97
6.	Final Report	10/30/97

PROJECT SUMMARY

PROJECT TITLE & ID: Integration of Radiotelemetry, Remote Sensing and GIS; CS-363

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: Department of Energy

LAB: Savannah River Technology Center - Aiken, SC

PRINCIPAL INVESTIGATOR: Dr. Lynn D. Wike

FY 1997 FUNDS: $100K

OBJECTIVE: The objective of this project is to provide the technical means to accurately and efficiently gather data to support ecological research. Integration of existing automated radiotelemetry technology with Global Positioning System (GPS), Geographic Information System (GIS)/Heuristic Optimized Processing System (HOPS), and land cover information, will increase efficiency, accuracy, and availability of habitat and land cover use data necessary for a variety of ecological analyses including: waste site characterization; ecological risk assessment; performance and success of ecosystem restorations; habitat use of animal species of concern, such as those listed as threatened or endangered.

TECHNICAL APPROACH AND RISKS: The principal technical approach is to integrate existing telemetry hardware (previously developed by SRTC) with other available remote sensing technology (GPS) and information management systems (HOPS). This will be accomplished through use of the existing automated radiotelemetry hardware and its control software and the development of interfaces to integrate the telemetry data with existing GPS technology and habitat contour information in an accessible package in HOPS. Full scale field research will provide testing and verification of the technical approach. Development of remote access of telemetry equipment for data downloading through satellite or cellular phone link will facilitate the planned off-site deployment of the system.

ACCOMPLISHMENTS: This system will supply data density on habitat use that is orders of magnitude more comprehensive than that possible with current systems. This will reduce the costs and increase the quantity of data acquisition. In FY 1996, the project completed initial field trials and commenced production of a documentary video.

BENEFIT: Data collected and analyzed with the proposed system is useful and necessary for many compliance related activities, such as characterization of waste sites prior to ecological risk assessment, actual effect and vectors in indicator organisms chosen as ecological risk assessment endpoints, threatened and endangered species issues, Natural Resource Damage Assessment (CERCLA) activities, and recovery of population and habitat use within restored ecosystems. The capability of the radiotelemetry system to supply data

density on habitat use is orders of magnitude greater than currently possible and will allow much more precise assessment of species habitat utilization. This will reduce the cost of acquiring such information. Parameters like habitat contours, patterns of habitat use, home range, and behavioral use of space are currently difficult and time consuming to determine but are important considerations in the evaluation of exposure and ecological risk. The ability to precisely evaluate these parameters will greatly improve the accuracy of ecological risk assessment activities.

FY 1997 Milestones	Planned Date
1. Complete Field Portion of System Test	10/01/96
2. Complete Video Documentary of Program	11/01/96
3. Complete Processing of Data from Field Test	12/01/96
4. Draft Manuscripts for Publication re: First Test, Trapping Programs, Habitat Contours, Edge Effect	01/01/97
5. Acquire Real-Time Processing Equipment for GPS	02/01/97
6. Demonstrate HOPS Interface	03/01/97
7. Plan Remote Access Telemetry Upgrades	04/01/97
8. Demonstrate Equipment at Non-SRS Location with Long-Term Deployment	07/01/97
9. Final Report	11/30/97

PROJECT SUMMARY

PROJECT TITLE & ID: Strategic Natural Resource Management Methodology; CS-373

RESEARCH CATEGORY: 6.3 Advanced Development

LEAD AGENCY: Department of Energy

LAB: Argonne National Laboratory - Argonne, IL

PRINCIPAL INVESTIGATOR: Dr. Ronald C. Sundell

FY 1997 FUNDS: $430K

OBJECTIVE: The project objective is to create a Strategic Natural Resources Management (SNRM) methodology and develop a decision-support system that will meet the planning needs for biological conservation and resource management on Department of Defense (DoD) installations and Department of Energy (DOE) sites. This proposed decision-support system, called the Integrated Dynamic Landscape Analysis and Modeling System (IDLAMS), will (1) allow land use conflicts to be identified and evaluated, (2) define value-based alternatives, and (3) determine solutions to long-term land stewardship issues. This project offers a planning framework and a technology that will be transferred to the installation site manager by providing pertinent resource information and a set of computer tools linked to their existing geographic information system (GIS).

TECHNICAL APPROACH AND RISKS: The technical approach incorporates various dynamic landscape modeling components (e.g., training disturbance factors, succession) and integrates them with a GIS, and a decision-analysis system (e.g., a value-based tradeoff analysis program, optimization procedures, rule-based expert system). This dynamic, integrated model will be accessed by the natural resources planner via a graphical user interface (GUI). The GUI allows the user to input data, make assumptions, and set modeling parameters through a series of prompts while the models and GIS operate in the "background," thereby allowing the planner to implement the program without significant knowledge of computer programming or GIS operations. The major modeling component is the development of a vegetation dynamics model. In addition, the approach will use methods that can (1) incorporate guidelines for determining the spatially explicit processes that occur within a study site; (2) use value-based modeling to asses tradeoffs among management objectives (e.g., reduce soil erosion, enhance the training mission, provide suitable wildlife habitat), resource strategies (e.g., planting trees or grass).

ACCOMPLISHMENTS: In FY 1996, the project continued with the overall development effort, including adding cost functions, analyzing Fort Riley remote sensing data, refining the graphical user interface, and initiating the Fort McCoy testing and refinement effort. A major FY 1996 task concentrated on developing and implementing an improved vegetation model

which incorporates Military Impact Miles, grass planting, and fire burning inputs as exact numbers rather than probabilities.

BENEFIT: This project's scientific approach and resulting IDLAMS system will enable resource managers to quantify the effects of land management actions, both spatially and over time. Such an approach will reduce costs, enhance land use management responsiveness and effectiveness, disencumber military operations, enhance environmental compliance, and reduce conflicts between competing land uses. The system should also be usable at DOE and other federal facilities and for resource management on federal lands. In this way, dual-use technology will be developed with broad applicability to Federal agencies. In order to preserve multiple endangered species, cultural resources, biological diversity, and geological resources, it is necessary to recognize that their preservation may conflict with each other and with site military operations. A complex compromise will usually be required, but there may be hundreds of possible compromise land-use strategies. The IDLAMS methodology allows these strategies to be searched and compared to find the best ones.

FY 1997 Milestones	Planned Date
1. Project Summary and Direction Update	11/29/96
2. Final Past Land Use Framework	02/28/97
3. Ft. Riley Prototype Field Test/Refinement	02/28/97
4. Ft. McCoy Prototype System	03/31/97
5. Decision Analysis Field Test/Refinement	04/30/97
6. In-Process Review	05/31/97
7. Ft. McCoy Field Test/Refinement	06/30/97
8. Draft Technical Documents	07/31/97
9. Final Program and Reports	11/30/97

PROJECT SUMMARY

PROJECT TITLE & ID: Threatened, Endangered, and Sensitive Resources; CS-507

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: U.S. Army

LAB: Construction Engineering Research Laboratories - Champaign, IL

PRINCIPAL INVESTIGATOR: Dr. David J. Tazik

FY 1997 FUNDS: $460K

OBJECTIVE: Growing numbers of threatened, endangered, and sensitive species (TES) found on military lands increasingly result in: (1) mission constraints and impediments to land acquisition, potentially leading to reduced defense readiness; (2) lengthy and costly litigation; and (3) criminal and civil penalties. Major objectives of this research are to continue efforts to manage TES habitats, and to mitigate the effects of Army-unique impacts. Specific technical objectives are to: (1) develop regional guidelines for TES habitat/community evaluation and management; (2) evaluate approaches, methodologies, and techniques to enhance conservation of TES plant population, (3) develop conceptual models of impacts of smokes, obscurants, and CS agents on TES and make predictive assessments of effects of selected material and species.

TECHNICAL APPROACH AND RISKS: Regional TES management strategies will be developed for the Southeast Region using a plant community framework. Characterization, status and management requirements will be defined for each plant community type and associated species based on the literature and coordination with regional experts. Management strategies will be developed that apply collectively to species with similar habitat requirements/plant community associations. TES plant populations enhancement approaches will also be evaluated for use by installation managers. We will scope the issue, evaluate specific enhancement techniques, and demonstrate specific guidelines. Small-scale field and greenhouse studies will be carried out. Impacts of smokes, obscurants and CS on plants and animals will be evaluated. Toxicity levels will be determined for selected species based on existing information and supplemented by laboratory studies as needed. Emphasis will be placed on species most likely to be affected. Up to two species will be selected for more detailed study based on this risk assessment. A conceptual model will be developed for evaluating such impacts.

ACCOMPLISHMENTS: In FY 1996, the regional habitat strategies subcomponent completed two ecological community reports and five species profiles, as well as an assessment of habitat characterization methodologies. The smokes/obscurants subcomponent developed a research strategy to address remaining questions about potential effects of fog oil on the

Red-Cockaded Woodpecker, including a toxicity study of fog oil to nestlings and an investigation of fog oil obscurant penetration into nest cavities and the effects of cavity orientation. The effort also initiated a study to determine toxicity characteristics of fog oil obscurant on nestling surrogates for the Red-Cockaded Woodpecker and obtained detailed information on DoD dispersion models for smokes/obscurants.

BENEFIT: These efforts contribute substantively to a comprehensive, systematic, and integrated approach to TES management on military lands. Resulting products will support the Army's environmental and endangered species management strategies, and aid in efficiently meeting Army TES policies and regulatory requirements. Through this effort, the military will develop and demonstrate scientific and technical leadership in the management of TES. We will thus be better able to integrate TES considerations with military activities while avoiding mission impacts. On-going interagency coordination will yield benefits at the national, regional, and local levels.

FY 1997 Milestones	Planned Date
1. Initiate Collection of Field Sample for Fog Oil Concentration Analysis	11/31/96
2. Complete Final Species Profiles	12/31/96
3. Military Impacts Manuscript to Editor	12/31/96
4. Develop Management Strategies and Techniques	04/30/97
5. Complete Avian Laboratory Toxicity Study	04/30/97
6. Complete Prototype Regional Habitat Handbook	09/30/97
7. Complete Model Integration for GIS	09/30/97
8. Final Report on Field/Germination Effort	10/30/97
9. Two Peer Review Publications to Sponsor for Review	11/30/97

PROJECT SUMMARY

PROJECT TITLE & ID: Digital Terrain Modeling and Distributed Soil Erosion Simulation/Measurement for Minimizing Environmental Impacts of Military Training; CS-752

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: U.S. Army

LAB: Construction Engineering Research Laboratories - Champaign, IL

PRINCIPAL INVESTIGATOR: Dr. Steven Warren

FY 1997 FUNDS: $700K

OBJECTIVE: The objective of this project is to develop methods and tools for prediction of the spatial and temporal distribution of runoff, soil erosion, and sediment deposition within watersheds. Soil erosion and consequent siltation of waterways have long been major environmental concerns on military installations. Most existing approaches to erosion/deposition modeling rely on lumped-parameter semi-empirical relationships developed for agricultural fields. Such approaches are unable to provide consistent results for watershed-scale runoff and erosion processes. Another primary limiting factor is the inability to accurately represent the terrain in a digital form necessary for high resolution watershed-scale erosion and sediment transport modeling. The development of new-generation technical tools to model distributed surface erosion and runoff in complex terrains is a necessity. Such tools will provide a basis for predicting the environmental impacts of military-related activities and for the optimization of land rehabilitation programs for installations.

TECHNICAL APPROACH AND RISKS: The research project incorporates the following parallel efforts: a) develop multivariate spline interpolation methods to support terrain modeling and processing field data, b) completion of a distributed model of rainfall-runoff processes, c) further development of the unit stream power theory approach to the Universal Soil Loss Equation to improve prediction of erosion, add prediction of deposition and allow application of the model in complex topography, d) develop a multi-dimensional application of the detachment/transport capacity theory approach to erosion and sediment prediction as contained in the Water Erosion Prediction Project (WEPP), e) develop vehicle-soil-climate interaction model based on field measurements of soil and hydrologic parameters, f) collect in-stream sediment data for validation of the proposed model applications, g) enhance visualization techniques supporting the design and communication of dynamic erosion and sediment transport model results.

ACCOMPLISHMENTS: In FY 1996, new, physically-based methods for analysis of the spatial distribution of high erosion risk areas and depositional locations were developed using the unit stream power theory. Rainfall/runoff and sediment transport sub-models were developed and validated to allow modeling of sediment movement during storms. These modeling efforts were enhanced by newly developed visualization techniques. Multivariate spline interpolation for terrain analysis has also been added. These terrain modeling and erosion/deposition risk assessment techniques were demonstrated on both military and non-military lands.

BENEFIT: This project will improve the capability to generate accurate digital elevation models and perform topographic analyses for various terrain related applications. There will be improved capability to estimate erosion/deposition potential as an input for choosing the optimal land use management and rehabilitation programs. Modeling of erosion and deposition will assist land managers and trainers in optimizing training schedules, delineating training areas, and monitoring changes over time. The models will also assist in maximizing availability of military lands with minimal impact to natural resources, especially to soil and vegetation. The overall net result of this research will be improved land management and reduced land maintenance costs.

FY 1997 Milestones	Planned Date
1. Compile Existing Mobility Data for Use in Erosion/Deposition Model	05/30/97
2. Provide Data to Validate Rainfall-Runoff Model	06/30/97
3. Provide Data to Validate Erosion/Deposition Model	08/30/97
4. Incorporate Distributed Critical Shear Stress into Erosion Models	09/30/97
5. Incorporate Selected Erosion Control Practices into Erosion/Deposition Model	09/30/97

PROJECT SUMMARY

PROJECT TITLE & ID: Phased Array Acoustic Detection of Artifacts; CS-753

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: U.S. Army

LAB: Construction Engineering Research Laboratories - Champaign, IL

PRINCIPAL INVESTIGATOR: Dr. Charles Marsh

FY 1997 FUNDS: $250K

OBJECTIVE: Once a cultural or archeological resource site is identified it must then be assessed in order to determine its significance. Currently the costs associated with the National Register of Historic Places (NRHP) Phase II eligibility assessment of cultural and archeological resources are quite high. The objective of this work is to develop a method using acoustics to more cost effectively assess sites by avoiding the usual detailed excavation.

TECHNICAL APPROACH AND RISKS: Acoustic sound waves can non-destructively transmit into and through the ground. These waves can be used to probe beneath the surface by being reflected off of media of higher relative density (i.e. bone, ceramic, stone, glass) than the surrounding medium and then be detected. The main thrust of this effort will be to develop a system using a phased array of ultrasonic/acoustic transducers which can accurately image sub-surface features of differing densities. By varying each transducers time delay and input amplitude, the focused ultrasonic/acoustic probe can be steered to examine successive control volumes beneath the surface. Reflected signals are then detected and, through computer imaging and enhancement, the location of possible artifacts can be identified while also gaining information about their shape and dimension. The predictive capability will be compared to actual archeological findings under varying conditions in order to determine reliability. The main challenges of this work will be in the areas of signal attenuation and signal processing/analysis.

ACCOMPLISHMENTS: In FY 1996, progress included the design of the computer controlled movement system, selection of targets for quantitative assessment of imaging ability/resolution, and the preparation of computer algorithms for the various approaches to signal processing intended for use with the acoustic data.

BENEFIT: The main benefit is to be able to non-destructively probe beneath the earth's surface to assess possible buried artifacts at a fraction of the cost associated with excavation. This would allow for the more efficient use of limited excavation resources and help speed the overall assessment of sites. In the Army alone, there are approximately 120,000 archeological sites of which only 10 percent have been assessed and the significance of the site determined. A Phase

II eligibility assessment for the NRHP typically costs $10K to $30K per site. In addition, this method will be useful in the compliance with the requirements stated in the Native American Grave Protection and Repatriation Act (NAGPRA). An additional benefit would be the rapid assessment capability employed on construction sites when an unanticipated discovery of a site occurs thus avoiding both delays and damaging artifacts. The use of a Navy developed phased array provides considerable leveraging for this project. To develop the unit being borrowed from scratch would cost approximately $500k. In addition, separate funding is being used to develop and install the Controlled Archeological Test Site (CATS) on which the imaging capabilities are being tested and refined.

FY 1997 Milestones	Planned Date
1. Adapt ARL Prototype Transducer/Detector Array for Imaging Optimization	10/30/96
2. Wire Computer Interface and Begin Optimization of Signal Processing for Imaging	10/30/96
3. Test ARL Prototype at CATS Test Site	11/30/96
4. Interim Report	12/30/96
5. Develop Control and Imaging Software	03/30/97
6. Submit Journal Paper on Soil Acoustic Properties Results	05/30/97
7. Develop Detailed Design for Field Prototype with All Supporting Information	07/30/97
8. Hold Formal Go/No-Go Technical Review	08/30/97
9. Technical Review Results/Comments to TTAWG	09/30/97

PROJECT SUMMARY

PROJECT TITLE & ID: Ecological Modeling for Military Land Use Decision Support; CS-758

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: Department of Energy

LAB: Oak Ridge National Laboratory - Oak Ridge, TN

PRINCIPAL INVESTIGATOR: Dr. Virginia H. Dale

FY 1997 FUNDS: $600K

OBJECTIVE: The analyses for land use decisions require spatially-explicit ecological models that include the spatial distribution of habitat characteristics, biological population parameters, disturbance characteristics, geophysical changes, and landscape ecology phenomena. A capability is needed that can define the probability of changes in valued resource attributes, identify their measurements, and provide the source information required to support land-use decisions. The purpose of this research project is to develop an integrated approach that incorporates the ecological models, their input assumptions, assessment endpoints, and a user interface into a useful application for DoD land managers.

TECHNICAL APPROACH AND RISKS: Development will continue on ecological models to assess the impact of DoD activities on natural resources and will focus on the loss/alteration of habitat. Evaluating the risk to habitats is expressed as the probability of a change in the abundance of groups of species, habitat diversity, or landscape pattern. Model evaluation will be based on data from Fort Knox, KY. The sensitivity of the models will be tested with the wide range of land management issues and data. The field test includes simulating ecological resource changes from a particular land management practice (e.g., location and scheduling of training exercises, land restoration, etc.) with ecological models and spatially-explicit ecological and geographical data. The results of the simulations will be compared with actual changes from previous activities. Data and experience from DoD and DOE sites will support the basis for the models.

ACCOMPLISHMENTS: In FY 1996, the project developed a preliminary territorial migrant population model and completed field testing of land use/land cover maps and three habitat models at Fort Knox, KY.

BENEFIT: This research will provide a quantitative method for assessing plans to maintain and conserve the natural resources required for DoD missions. The results will allow DoD land managers to analyze the potential impact of selected land-use activities on natural resources. Maps showing potential risks to different land cover types will also be produced. Integrating ecological models into a spatial context for land management will result in a clearer priority for

ecological information, improved decisions, and fewer specialized management programs in the future. Besides its use for management of natural resources, the proposed research is directly applicable to (1) planning for facility closures and realignment; (2) evaluating natural resource management plans; (3) supporting compliance environmental laws such as the Endangered Species Act, the National Environmental Policy Act; and (4) developing integrated risk assessments that address cumulative effects.

	FY 1997 Milestones	Planned Date
1.	Issue Strategy for Developing Multi-Species and Meta-Population Models	06/30/97
2.	Implement GIS-based Habitat Model for Red-Cockaded Woodpecker	07/30/97
3.	Field Test Habitat Model for Red-Cockaded Woodpecker at Fort Stewart	08/31/97
4.	Implement Spatially-Explicit Demographic Model for Red-Cockaded Woodpecker at Fort Stewart	09/30/97
5.	Develop Karner Blue Butterfly Population Model for Incorporation into IDLAMS	09/30/97
6.	Interim Report to SERDP	12/31/97

PROJECT SUMMARY

PROJECT TITLE & ID: Advanced Biotelemetry for Resource Management; CS-759

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: U.S. Army

LAB: Edgewood Research, Development, and Engineering Center - Edgewood, MD

PRINCIPAL INVESTIGATOR: Dr. William S. Seegar

FY 1996 COMPLETED PROJECT

OBJECTIVE: Acquisition of good scientific information on free ranging organisms to fully elucidate their relationships with habitat and military land use activities is critical to the development and implementation of effective natural resource management plans. Such plans, in turn, allow the DoD to maintain biodiversity, conserve natural resources, and comply with environmental laws and regulations. This project has developed sophisticated remote sensing biotelemetry technology and methodologies with which to study wildlife on military installations while minimizing disruption to military activities.

BENEFIT: The new telemetry capability will provide more frequent and more accurate location information than currently feasible, as well as behavioral information to provide state-of-the-art research data with little interference with mission activities. Such technology will enable planners and managers to meet both military and environmental requirements quickly, with accurate information, and with minimal interruption to regular base activities.

ACCOMPLISHMENTS: Development of a new, highly capable generation of satellite tracking system that contains a Global Positioning System receiver and a suite of advanced sensors was completed in FY 1996. These advanced sensors include a digital acoustic sensor, along with sensors to provide meteorological and animal physiological data. Miniaturized transmitters have been applied to migrating Arctic Peregrine Falcons and Swainson's Hawk populations, as well as several other species on a variety of military installations.

TRANSITION: Prototype systems from all phases of development are being completed and are being transitioned to several field programs for test and evaluation of performance. These systems are also being applied in a proof-of-principle demonstration to mitigate costly bird strikes by military aircraft.

PROJECT SUMMARY

PROJECT TITLE & ID: Initial Evaluation for Assessing Military Training and Testing Impacts on Natural and Cultural Resources; CS-1048

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: U.S. Army

LAB: Construction Engineering Research Laboratories - Champaign, IL

PRINCIPAL INVESTIGATOR: Dr. Keturah Reinbold

FY 1996 COMPLETED PROJECT

OBJECTIVE: To identify methodological approaches, procedures, and data requirements, as well as existing sources of data, and to quantitatively assess military training and testing impacts on natural and cultural resources in all different types of environments.

BENEFIT: This work provides a guide for the collection of valid, quantitative data to provide assessments of impacts of military activities on natural and cultural resources.

ACCOMPLISHMENTS: In FY 1996, SERDP initiated and completed this one year study. This framework establishes a new, risk-based approach to natural and cultural resources management on military installations.

TRANSITION: The guide is intended to be accepted by regulatory agencies. The framework, in turn, is serving as the foundation for future research in the FY 1997 new start project **CS-1054** to fully develop a risk management paradigm.

PROJECT SUMMARY

PROJECT TITLE & ID: Develop and Demonstrate a Risk Assessment Framework for Natural and Cultural Resources on Military Training and Testing Lands; CS-1054

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: Department of Energy

LAB: Oak Ridge National Laboratory - Oak Ridge, TN

PRINCIPAL INVESTIGATOR: Dr. Glen Suter

FY 1997 FUNDS: $330K

OBJECTIVE: The objective of this effort is to develop a structured, scientifically valid risk assessment framework that can be rapidly and inexpensively applied to assess risks of single, multiple or cumulative impacts of military training and testing activities on natural and cultural resources. This framework will incorporate physical, chemical, and biological stressors, including noise, and their direct and indirect effects, short and long term, on natural and cultural resources. Feasibility of linking Incremental Cost Analysis with the risk assessment framework will be examined.

TECHNICAL APPROACH AND RISKS: Following agreement on direction and policy by an interagency, interservice Steering Committee, and an initial scoping workshop involving the Advisory Group and other users, the project will proceed by an iterative process of (1) consultation with users and DoD experts concerning a set of assessment issues, (2) summarization and organization of the consultation results, (3) framework development, and (4) review and direction by the advisory group. The results of the initial SERDP risk assessment development project currently being conducted by CERL and collaborators (CS-1048) will serve as the first iteration of steps 1 and 2. The first iteration of the four-step process will be used to develop the first level (conceptual) framework. The later iterations will be devoted to development of a second level (implementation) framework component for each of a series of generic types of stressors associated with training and testing. Examples could include soil and vegetation disturbance by vehicles, use of smokes and obscurants, overflights, fires, and spills of fuels. Each of these intermediate products will be designed so as to be usable by itself within the appropriate sphere of concern.

Technical risks include the scientific issues of environmental complexity and the methodological issues of designing a framework that is useful. The scientific issues are in a sense more manageable because the participants are experienced in the assessment of risks of diverse activities on complex sites and because the project is intended to identify gaps in knowledge and not to fill them all. The methodological problems of developing a framework that is sufficiently

simple in its implementation to be useful but sufficiently complex to incorporate all major issues is more difficult. In addition, the framework will need to be relevant to three services with facilities in a variety of environments and a variety of existing data, GIS systems, environmental models, etc. This problem will be addressed by using a hierarchical approach to organizing the framework, maintaining flexibility to substitute equivalent assessment tools, and by regular consultation with potential users.

BENEFIT: Definition of more specific risk assessment framework components for major military training and testing impact categories will lead to standardized data and models. Specific examples include:

- Estimating risks of specific testing and training activities so as to determine their acceptability,
- Determining the efficacy of potential mitigation measures,
- Comparing risks of alternative testing and training plans,
- Comparing risks of testing and training activities at alternative facilities, and
- Comparing risks of testing and training activities with alternative uses for the land.

By supporting a risk-based approach, the tools provided from this research will assist decision makers within DoD to identify their knowledge gaps and prioritize their research and data collection needs for natural and cultural resources management to address the greatest risks first.

FY 1997 Milestones		Planned Date
1.	Draft Framework Criteria Based on Review of Prior SERDP and Related Projects and Advisory Contributions	02/15/97
2.	Conceptual Framework w/ Input from Steering, Advisory Groups	03/15/97
3.	Submit Conceptual Framework to SERDP SAB for Review	04/15/97
4.	Workshop - Review and Revise Criteria and Conceptual Framework	04/15/97
5.	Select Assessment Tools for Implementation Framework	08/15/97
6.	Develop Options to Link Incremental Cost Analysis and Risk Assessment	09/15/97

PROJECT SUMMARY

PROJECT TITLE & ID: Analysis and Assessment of Military and Non-Military Impacts on Biodiversity: Framework for Environmental Management on DoD Lands Using Mojave Desert as A Regional Case Study; CS-1055

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: Environmental Protection Agency

LAB: Environmental Research Laboratory - Corvallis, OR

PRINCIPAL INVESTIGATOR: Dr. David Mouat

FY 1997 FUNDS: $250K

OBJECTIVE: The primary objective of this research is to provide DoD with techniques, tools, and training to carry out its military mission in the context of regional management of biodiversity and related ecological, stakeholder, as well as cultural and environmental resource concerns. The project develops and expands research and technology developed at MCB Camp Pendleton to address environmental problems at the regional scale in the western Mojave Desert (and will be coordinated with adjacent DOE landholdings). It will analyze the impacts of military and non-military stressors on patterns of biodiversity and related environmental resources and will assess the impacts future land uses are likely to have on patterns of biodiversity. A strategic goal of the project is to enable the entire set of western Mojave installations to manage their resources unilaterally within the context of the region as a single entity as opposed to independent management without the benefit of their unity. The ultimate deliverable will be the transfer to the installations and implementation of techniques and training developed during the project.

TECHNICAL APPROACH AND RISKS: The project employs an integrated technical approach consisting of four components or phases. The development phase consists of the development of a QA/QC plan and a peer-reviewed experimental design, the initiation of a spatially-oriented data base management and decision support system, the organization of a military and non-military stakeholder group to identify environmental issues and human valuations of the regional ecosystem both within and outside the military context, and identification of military and non-military stressors. Technology transfer activities will be initiated to implement the framework developed for MCB Camp Pendleton at MCAGCC 29 Palms. The basic methodology for deriving habitat information through vegetation - terrain correlation will be established. The data assembly phase consists of continued work in deriving vegetation information for habitat characterization, the development of comprehensive data bases for biotic and abiotic resources, and the determination of key species (including the Desert Tortoise) along with their habitat requirements. Much of this work will involve an interaction with ongoing Legacy Program

activities (for their data bases) through the National Biological Service and other groups. The analysis and assessments phase consists of determining habitat relationships for the Desert Tortoise and other key species, assessing management strategies for the Desert Tortoise and other key species, assessing the "sweep" potential for using certain key species (e.g. the Desert Tortoise) for deriving habitat and management strategies for other species, and evaluating the effects of existing land uses and other stressors on habitat and biodiversity. The modeling and products delivery phase involves modeling the effects of future land use scenarios on stressors and on the likely impacts on biodiversity and related environmental resources. It also involves reporting and publication coordination, stakeholder briefings, and technology transfer activities. A number of technical risks are associated with the proposed activities. Some involve the necessity of having qualified individuals at the installations to implement the output products produced. This risk also involves successful integration of the installations themselves. In addition, it is imperative that appropriate questions and issues are asked and addressed. Possible incompatibility of disparate data bases is another potential risk.

BENEFIT: A principal benefit of the project will be a capability of the military to evaluate impacts of both DoD and non-DoD stressors (such as off-road vehicle use and suburban development) on military issues in an integrated manner. Through integrated regional ecosystem management, the military will far more effectively be able to negotiate biodiversity and other ecosystem management issues with surrounding stakeholders, ensuring minimal environmental damage while maintaining and enhancing the military mission. Results of the project will further provide the military with techniques, tools, and training to evaluate the impacts of future development and land uses on the environment and to be able to coordinate responses.

FY 1997 Milestones	Planned Date
1. Develop QA/QC Plan	03/15/97
2. Develop Military Stakeholder Focus Group	03/15/97
3. Initiate Data Base Management System	04/15/97
4. Initiate Technology Transfer at 29 Palms	05/15/97
5. Identification of Problems/Issues	08/15/97
6. Interim Report to SERDP	09/15/97

PROJECT SUMMARY

PROJECT TITLE & ID: Marine Mammals and Low Frequency Sound; CS-1069

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: U.S. Navy

LAB: Office of Naval Research - Arlington, VA

PRINCIPAL INVESTIGATOR: Dr. Robert C. Gisiner

FY 1997 FUNDS: $600K

OBJECTIVE: To develop state-of-the-art monitoring and mitigation capabilities for assessing the impacts of manmade low frequency sound on the marine environment, with emphasis on marine mammals. Marine mammals are protected as a group by special legislation, the Marine Mammal Protection Act (MMPA). In addition, many marine mammals are listed under the Endangered Species Act because their numbers have been severely reduced by hunting and habitat destruction. We do not currently have an adequate understanding of the effects of manmade sound on the environment, but we anticipate that large whales (which emit low frequency sound for sensing and communication), and other marine mammals which dive into the deep sound conducting channel (SOFAR channel), are most vulnerable to exposure to manmade, low frequency sound sources. This program aims to collect data on this question while exploring new technology that will better enable us to monitor the marine environment.

TECHNICAL APPROACH AND RISKS: The technical approach is based on the data required to assess the impact of manmade sound on marine mammals. One aspect of this process is measurement of received sound levels around the sound source to calibrate the effectiveness of planning models of transmission loss (TL). Acoustic monitors may be bottom-mounted (pop-up buoys), moored, drift, attached to a mobile platform like a ship, or attached to marine mammals. A second aspect of the process involves assessing the abundance and distribution of marine mammals around the sound source. This is accomplished through aerial and ship-based surveys of the site using both visual and acoustic monitoring. The third aspect of the process involves assessing the response of marine mammals to the sound received from the source. Approaches can include attaching remote sensors to the animals themselves to monitor movements, heart rate, vocal activity, and other indices of response. Follow-up studies of long term effects will make use of a pool of individually identifiable individuals obtained from ship-based photo-identification. Risks are primarily associated with climatic variability that might make comparison between years difficult and might also prevent completion of sampling and experiments due to bad weather.

BENEFIT: There are two areas of benefit from this project. One is the acquisition of data on the effects of manmade low frequency sound on marine mammals. There is relatively little data on

this subject and therefore little in the way of regulatory guidelines or standardized assessment and mitigation procedures. The second area of benefit covers the development of technology to improve detection and monitoring of marine mammals.

FY 1997 Milestones		Planned Date
1.	Aerial Surveys of Pioneer Seamount (CA)	02/15/97
2.	Pioneer Seamount Bottom-deployed Acoustic Monitoring Devises	03/15/97
3.	Collection of Empirical Acoustic Measurements	04/15/97
4.	Track Translocated and Naturally Migrating Elephant Seals	05/15/97
5.	Remote Acoustic Monitoring using SOSUS	06/15/97
6.	Photographic Identification to Document Occurrence of Specific Whales	07/01/97
7.	Remote Acoustic Sensing Using SOSUS Follow-up	08/15/97
8.	Interim Report to SERDP	11/15/97

APPENDIX D
Pollution Prevention Project Summaries

PROJECT SUMMARY

PROJECT TITLE & ID: DoD/DOE Clean Agile Manufacturing of Energetics; PP-63

RESEARCH CATEGORY: 6.3 Advanced Development

LEAD AGENCY: U.S. Navy

LAB: Office of Naval Research - Arlington, VA

PRINCIPAL INVESTIGATOR: Dr. Richard Miller

FY 1997 FUNDS: $600K

OBJECTIVE: The objective of this program is to develop energetic materials and processing technologies to provide concepts for reconfiguring existing propellants, explosives, and pyrotechnics (PEP) life-cycle facilities into clean, agile operations that will function economically with total life-cycle wastes reduced by up to 90 percent from a 1992 baseline. This project develops new chemicals and processes to enable pollution prevention simultaneously with providing increased PEP energy and lower production costs.

TECHNICAL APPROACH AND RISKS: The technical approach is to simulate government and industry PEP production facilities to predict life-cycle pollution. Pollution prevention technologies will be experimentally tested in existing facilities. Facility design concepts will be developed, including descriptions of products, chemical engineering unit operations, utility requirements, regulatory and qualification approaches, and safety constraints on operation. During 1997, a pilot plant for manufacturing thermoplastic elastomers using supercritical (or liquid) carbon dioxide as the solvent will be assembled at Aerojet Corporation in Sacramento, California. The Massachusetts Institute of Technology will complete its SERDP sponsored work adapting the chemical batch process simulator known as Batch Design Kit to batch processes used in the manufacture of propellants and explosives.

Thermoplastic elastomer (TPE) manufactured by Thiokol in Utah will be used by the Naval Surface Warfare Center Indian Head Division to demonstrate loading of TPE-based propellant or explosive into a warhead or sub-scale rocket motor.

The risk is that PEP safety issues and policies might prohibit the adoption of the pollution prevention methods for manufacturing military PEP. The risk is mitigated through experimental studies which will be conducted to demonstrate a range of products and processes that are operationally safe in an explosive manufacturing operation. These experiments will demonstrate new PEP materials and processes that are practical for safe, cost-effective, environmentally clean insertion into the PEP life-cycle, and satisfy ordnance performance requirements.

ACCOMPLISHMENTS: In FY 1996, Sandia and Battelle Pacific Northwest Laboratory, the DOE co-performers for this project, completed life-cycle inventory and life-cycle impact assessment using the LCAD and EcoSys software in case studies for synthesis of TNAZ and CL-20. Also, an innovative injection process was demonstrated for loading PBXN-107 into the BLU-97 submunitions with a lower rejection rate than the present system.

BENEFIT: By 1998, this project will provide automated tools for PEP life-cycle analysis and a conceptual approach, based on these tools, for reconfiguring existing PEP factories to reduce hazardous wastes by a factor of ten, almost twice the 1999 national goal for pollution prevention. This will mitigate price increases of future PEP products due to cost of complying with more stringent future environmental regulations. Satisfying regulations will help curtail factory shutdowns or unscheduled retirement of ordnance systems.

FY 1997 Milestones	Planned Date
1. Synthesize a thermoplastic elastomer (probably AMMO/BAMO) in supercritical (or liquid) carbon dioxide	06/01/97
2. Demonstrate recapture of ingredients from a thermoplastic elastomer (TPE) based PEP formulation	09/01/97
3. Demonstrate loading of TPE PEP formulation into BLU-97 (submunition) warhead	09/01/97
4. Batch Design Kit for PEP is completed by MIT	09/01/97
5. LCAD for PEP is completed by Battelle Pacific Norhtwest (based on the beta-test feedback from Picatinny Arsenal and NSWC Indian Head subject to the budget allocated by ONR)	09/01/97
6. EcoSys for PEP is completed by Sandia National Laboratories (based on beta-test feedback from Picatinny Aresenal and NSWC Indian Head subject to the budget allocated by ONR)	09/01/97

PROJECT SUMMARY

PROJECT TITLE & ID: Organic Protective Coatings and Application Technology; PP-65

RESEARCH CATEGORY: 6.3 Advanced Development

LEAD AGENCY: U.S. Navy

LAB: Naval Air Warfare Center Aircraft Division - Patuxent River, MD

PRINCIPAL INVESTIGATOR: Dr. Kevin Kovaleski

FY 1997 FUNDS: $600K

OBJECTIVE: To develop high performance, non-toxic, low volatile organic compounds (VOC) content coatings which provide protection against environmental degradation as well as passive countermeasures for Navy aircraft and weapon systems. The Navy currently uses numerous coatings due to their diverse functions, variety of substrate applications, and severe operational environment. The toxic inhibitors (i.e. lead, chromates, etc.) and high VOC contents of these coatings are released during painting operations as organic and toxic air emissions. Federal, state and local environmental agencies restrict these hazardous emissions through regulations such as the Clean Air and Water Acts, and local Air Quality Management District rules. OPNAV/CNO directives require significant reductions in the Navy's hazardous waste generation of which painting operations are a major contributor. Therefore, it is necessary to develop new high performance coatings which meet environmental restrictions and allow the Navy to continue painting operations.

TECHNICAL APPROACH AND RISKS: A full spectrum approach for reducing the VOC and air toxic emissions from protective coatings is being pursued. Research in reactive monomers & dilutents (low VOC polymer technology) is being used to produce low VOC binder systems for future aircraft coatings. New waterborne resin technology has allowed for the development of high performance topcoats. Also, several experimental compliant materials (a non-Cr, low VOC self-priming topcoat; one-component lacquers, non-toxic inhibitors, powder coats, and electrocoatings) will be investigated for this program. Self-priming topcoat has been authorized for Navy use and is currently being implemented at NADEPs. One component urethane coatings are being developed to replace high VOC lacquers for touch-up applications. Non-toxic inhibited primers and sealant coatings will replace current chromated materials. These materials are being optimized, service evaluated and then implemented for Navy use. Finally, conventional air spray which has a transfer efficiency of 28 percent will be prohibited by the CAA. Therefore, high transfer efficient application equipment such as air-assisted airless, electrostatic, and high volume low pressure (HVLP), was evaluated for painting operations. HVLP is currently being implemented at the NADEPs.

ACCOMPLISHMENTS: An in-house-formulated, non-chromated primer is now in operational use for coating a P-3 aircraft "beaver tail" component. Testing continues on a T-2 aircraft. A non-chromated conductive sealant was also evaluated in FY 1996.

BENEFIT: The development of non-toxic, VOC compliant coatings will enable the Navy to meet current and future environmental regulations and will reduce the total amount of hazardous waste generated by painting operations. Furthermore, these new materials will eliminate the need for installation of extremely expensive control equipment (i.e., $1M-5M per spray booth for VOC emission control and multi-filter systems for airborne HAPs). This effort is in direct support of Navy and DoD hazardous waste minimization policies/directives. This technology is being coordinated with commercial aerospace, coatings and equipment manufacturers to insure product availability for implementation.

FY 1997 Milestones	Planned Date
1. Optimize non-chromated A/C sealants	10/01/96
2. Initiate service demo of non-toxic powder coats	12/01/96
3. Complete resin evaluations for zero-VOC topcoat	01/01/97
4. Optimize formulations for zero-VOC topcoat	04/01/97
5. Service demonstration of non-Cr sealants	06/01/97
6. Initiate service demonstration of zero-VOC topcoat	07/01/97
7. Initiate spec revision and tech transfer of waterborne topcoats	09/01/97
8. Complete service demonstration of non-toxic powder coats	09/01/97
9. Complete service demonstration of non-toxic electrocoats	09/01/97

PROJECT SUMMARY

PROJECT TITLE & ID: Aircraft Maintenance Chromium Replacement; PP-66

RESEARCH CATEGORY: 6.3 Advanced Development

LEAD AGENCY: U.S. Navy

LAB: Naval Air Warfare Center Aircraft Division - Patuxent River, MD

PRINCIPAL INVESTIGATOR: Dr. Catherine Rice

FY 1997 FUNDS: $350K

OBJECTIVE: To replace chromates (Cr) currently used in aerospace materials and processes on Navy aircraft (A/C) and weapon systems. Chromium VI is a carcinogen and federal, state, and local agencies have issued regulations that limit or prohibit the use of chromated materials. Specifically, the 1990 Clean Air Act Amendment electrolytic chromium NESHAP and the San Diego Air Quality Management District electrolytic chromium rule restrict the emissions from these processes beginning in 1994. In addition, Service directives require significant reductions in hazardous waste generation, of which production and depot level maintenance chromated processes such as chromic acid anodizing and chrome containing materials are major contributors. To comply with these regulations while maintaining A/C operational readiness, chrome-free alternatives have to be developed and transitioned to fleet use.

TECHNICAL APPROACH AND RISKS: Non-chromate alternative materials and processes are being investigated to replace current chromated anodizing, pretreating and adhesive bond processes. This project identified the best alternatives to chromic acid anodizing (a common inorganic pretreatment for aluminum) from existing and developmental methods. The alternatives included thin sulfuric, phosphoric and Boeing's Aerospace Corp's Boric-Sulfuric Acid Anodizing (BSAA). Selected alloys evaluated to determine which replacement systems provided equivalent corrosion resistance and paint adhesion while maintaining the existing mechanical properties provided by chromic acid anodizing. The most promising alternative optimized and demonstrated at a Naval Aviation Depot. This approach is also being taken for the development of non-chromate conversion coatings (non-CCC). Chromate conversion coatings (CCC) replacement has been difficult due to the diverse mechanisms by which the CCC provides protection and protection and performance properties. In FY 1997 the Navy anticipates on providing non-SERDP funding for non-Cr conversion coatings ($75K) and for non-Cr adhesive bond coatings ($50K). In FY 1998 the Navy DEM/VAL money anticipated is $150K and $100K for the respective projects.

ACCOMPLISHMENTS: . A phosphoric acid anodization line was installed in FY 1996 at the Navy Cherry Point depot for aluminum bond pretreatments to replace the chromic acid

anodization line. A DoD Tri-Service study for titanium bond pretreatments was also initiated.

BENEFIT: The elimination of chromic acid anodizing, CCCs and chromated adhesive bonding materials, significantly reduces the total amount of chromium emitted from Navy operations. Replacement of chromic acid anodizing also eliminates the need for expensive emission control equipment, estimated at $700K capital and $250K annual operating costs per Depot facility. Furthermore, these alternatives reduce the amount of chromium disposal from Navy operations (estimated at 12 tons/year per facility). This technology is being coordinated with commercial aerospace, chemical and equipment manufacturers.

	FY 1997 Milestones	Planned Date
1.	Complete transition of non-Cr Al adhesive pretreatment	10/01/96
2.	Hold meeting on tech transfer of non-Cr conversion coating @ North Island	12/01/96
3.	Issue NAVMAR contract increment	01/01/97
4.	Begin lab evaluation of sol-gel non-Cr conversion coating	02/01/97
5.	Complete lab evaluation of sol-gel non-Cr conversion coating	04/01/97
6.	Initiate lab evaluation of reformulated VOC/non-Cr adhesive bonding primers for Al	03/15/97
7.	Complete optimization of reformulated low VOC/non-Cr adhesive bonding primers for Al	06/01/97
8.	Complete tech transfer of non-Cr conversion coatings at NADEP North Island	06/01/97
9.	Initiate service demo of low VOC/non-Cr Ti pretreatment	09/30/97
10.	Final Report due	03/15/98

PROJECT SUMMARY

PROJECT TITLE & ID: Solvent Substitution and Low VOC Cleaners; PP-67

RESEARCH CATEGORY: 6.3 Advanced Development

LEAD AGENCY: U.S. Navy

LAB: Naval Air Warfare Center Aircraft Division - Patuxent River, MD

PRINCIPAL INVESTIGATOR: Mr. Philip Bevilacqua

FY 1997 FUNDS: $350K

OBJECTIVE: To develop low Volatile Organic Compound (VOC) content and non Hazardous Air Pollutant (HAP) maintenance products for use on Navy aircraft (A/C) and weapon platforms. Naval aviation depot aircraft maintenance operations have been identified as major contributors to the hazardous waste generated by the Navy. Currently, solvents classified as Hazardous Air Pollutants (HAPs), such as methyl ethyl ketone (MEK), are used for surface pre-cleaning prior to painting and for purging paint spray equipment. Chemical paint strippers contain methylene chloride, which will be banned from use in stripping operations in 1997. Aircraft cleaning and corrosion preventive compounds used in routine aircraft maintenance operations are high in Volatile Organic Compounds (VOCs). The EPA Clean Air Act and local Air Quality Management District rules restrict the use and disposal of these hazardous materials. Therefore, non-HAP and low-VOC alternative maintenance products that meet regulatory criteria while maintaining aircraft operational readiness need to be developed and implemented.

TECHNICAL APPROACH AND RISKS: Cleaners must be effective on a diverse combination of soils from baked-on carbon to A/C greases and lubricants. Corrosion preventive compounds must protect various A/C metals against the corrosive effects of sea water. Non-HAP paint strippers must be effective on a variety of Navy paint systems. The best alternative materials from these efforts will be service demonstrated at a NADEP and transitioned to fleet use through specification modification. Technical risk is expected to be low and is due mainly to the uncertainty in finding new materials on structural components not adequately represented in testing evaluations. These risks will be minimized by attempting to establish feasability early in the study and by through materials comptibility evaluations further on. In FY 1997, the project anticipates $57K of non-SERDP funds for low-VOC pre-paint cleaner. In FY 1998, the project anticipates $290K of Navy DEM/VAL dollars for both low-VOC and non-HAP work.

ACCOMPLISHMENTS: The current military specification, MIL-C-85570, was revised in FY 1996 to include the requirements for the no-VOC aircraft exterior cleaner and the low VOC wheel well cleaner developed. The revised MIL-C-85570 is currently under review.

BENEFIT: The development of non-HAP, low-VOC maintenance chemicals will significantly reduce the total amount of hazardous materials generated by Navy maintenance facilities. This is particularly important considering the cost of the aircraft and weapon systems as well as the severely deleterious environment in which the Navy operates. This effort is being coordinated with commercial aerospace, chemical, and equipment manufacturers.

FY 1997 Milestones	Planned Date
1. Initiate investigation of low-VOC water-displacing corrosion prevention compound	12/01/96
2. Initiate investigation of non-HAP paint-purge solvent	12/01/96
3. Complete establishing technical feasability of low-VOC pre-paint cleaner	12/01/96
4. Complete evaluating non-HAP paint-purge solvent alternatives	03/01/97
5. Complete implementation of low-VOC aircraft exterior cleaner	03/01/97
6. Complete implementation of low-VOC wheel well cleaner	03/01/97
7. Complete development of low-VOC Corrosion Preventive Compounds (CPC)	06/01/97
8. Complete limited implementation of non-HAP strippers	06/01/97
9. Complete optimization of low-VOC CPC	09/01/97
10. Complete optimization of low-VOC pre-paint cleaner	09/01/97
11. Complete optimization of non-HAP paint purge process	09/01/97
12. SERDP Final Report due	03/01/98

PROJECT SUMMARY

PROJECT TITLE & ID: Recycle Boiler Nitrite Solution; PP-69

RESEARCH CATEGORY: 6.3 Advanced Development

LEAD AGENCY: U.S. Navy

LAB: Naval Facilities Engineering Service Center - Port Hueneme, CA

PRINCIPAL INVESTIGATOR: Dr. Richard Lee

FY 1996 COMPLETED PROJECT

OBJECTIVE: To develop an integrated and cost-effective process to denitrify hazardous sodium nitrite wastewater solutions, with minimal nitrate conversion, producing environmentally benign waste streams that meet disposal limits and can be disposed at a low cost.

BENEFIT: Provision of a treatment process for the millions of gallons of wastewater generated annually from marine boiler maintenance operations in which the Navy extensively uses sodium nitrite solution as a rust-preventing fluid.

ACCOMPLISHMENTS: A 5,000 gallon centralized boiler sodium nitrite recycle/treatment system was erected as an integral part of the existing facility located at the Naval Air Station North Island, San Diego, CA. This nitrite denitrification system has capabilities for recycling and storage of the nitrite solution for reuse, nitrite reduction using sulfamic acid, heavy metal precipitation, and neutralization for discharge.

TRANSITION: This technology is being transitioned to Navy.

PROJECT SUMMARY

PROJECT TITLE & ID: Recycling/Purification of Plating/Cleaning Baths; PP-70

RESEARCH CATEGORY: 6.3 Advanced Development

LEAD AGENCY: U.S. Navy

LAB: Naval Facilities Engineering Service Center - Port Hueneme, CA

PRINCIPAL INVESTIGATOR: Mr. Nick Stencel

FY 1996 COMPLETED PROJECT

OBJECTIVE: To develop innovative technologies for prolonging process bath life, and for recycling hazardous materials from spent process baths to reduce the generation of hazardous wastes.

BENEFIT: Development of bath purification technologies will provide in-process treatment of chrome plating and anodizing, electroless nickel, acid etching, and alkaline cleaning solutions. The effective life of these solutions could be extended up to 30 times. Navy-wide savings in disposal and material costs are estimated over $2 million per year.

ACCOMPLISHMENTS: Separation technologies including ultra/microfiltration, adsorption, electrodialysis, membrane electrolysis, and diffusion dialysis were evaluated and systems developed for removing contaminants from plating and cleaning solutions. Pilot testing of a crossflow filtration system for recycling alkaline cleaners which produced a 97 percent reduction in waste volume was completed. Field tests on a pilot diffusion dialysis system for purifying mineral acid baths were also initiated at the Tobyhanna Army Depot.

TRANSITION: Full-scale demonstration will continue into FY 1997 at the North Island Navy Depot and a Technology User's guide will be developed.

PROJECT SUMMARY

PROJECT TITLE & ID: Alternate Electroplating Technology; PP-71

RESEARCH CATEGORY: 6.3 Advanced Development

LEAD AGENCY: U.S. Navy

LAB: Naval Air Warfare Center Aircraft Division - Patuxent River, MD

PRINCIPAL INVESTIGATOR: Mr. Mark Roberts

FY 1997 FUNDS: $400K

OBJECTIVE: To replace hazardous plating processes (chromium, cadmium, cyanide, etc.) currently used on Naval aircraft (A/C) and weapon systems. Chromium and cadmium are heavy metal pollutants and carcinogens. The 1990 Clean Air Act Amendment (CAAA) as well as other EPA and State Departments of Environmental Resources regulations such as the CAAA Chromium Electroplating National Emission Standard for Hazardous Air Pollutants (NESHAP) restrict the emissions from these processes. In addition, Service directives require significant reductions in these hazardous wastes. Alternative plating processes need to be developed and validated in order to comply with these directives, while maintaining aircraft performance and operational readinesss.

TECHNICAL APPROACH AND RISKS: Cadmium plating is the leading inorganic corrosion preventive coating and is frequently used for fastners and other very tight tolerance parts because of the dual qualities of lubricity at minimal thickness and superior sacrificial corrosion protection. Chromium plating is used to restore components to original dimensions when material has been removed due to corrosion and/or wear damage. Replacements for chromium and cadmium will require similar mechanical and performance properties over the full spectrum of applications for which they are currently used. Electroless nickel (Ni) plating offers potential to replace a significant portion of chromium plating and will be demonstrated by establishing a full size prototype at the Cherry Point Naval Aviation Depot (NADEP). In addition, initial studies have indicated the potential for both Zinc-Nickel (Zn-Ni) and Tin-Zinc (Sn-Zn) electroplating baths to replace cadmium plating. The best cadmium replacement determined from the laboratory evaluation will be used for a full scale service demonstration at NADEP Cherry Point. Both the cadmium and chromium replacements will be transitioned to fleet use through specification modifications, technical manual revision and design changes.

ACCOMPLISHMENTS: Electroless nickel (Ni) plating offers potential to replace a significant portion of chrome plating and is now being used on Navy components in service where hard chromium plating would normally be used. Also, both zinc-nickel (Zn-Ni) and tin-zinc (Sn-Zn) electroplating baths are being evaluated to replace cadmium plating. This

technology is being coordinated with commercial airlines, equipment manufacturers and fastener manufacturers.

BENEFIT: The elimination of chromium and cadmium plating significantly reduces the total amount of hazardous materials emitted from Navy overhaul/repair operations. Elimination of chromium plating also eliminates the need for expensive emission control equipment required by CAAA and AQMD legislation (estimated at up to $1M per Depot facility). Furthermore, these alternatives significantly reduce disposal costs of chromium and cadmium from Navy operations. This effort is in direct support of Navy and DoD hazardous waste minimization policies and directives. Without the use of adequate replacements, aircraft operational readiness could be curtailed due to excessive environmental degradation and cost. This is particularly important considering the cost of Navy A/C and weapon systems as well as the severly deleterious environment in which the Navy operates. This technology is being coordinated with commercial airlines, equipment and fastner manufacturers.

FY 1997 Milestones	Planned Date
1. Complete the prototype low-phosphorus electroless Ni	01/01/97
2. Service demonstration of Zinc-Nickel electroplating complteted	01/01/97
3. Optimization of Tin-Zinc electroplating demonstrated	06/01/97
4. Fatigue testing of Cr alternatives completed	08/01/97
5. Service demonstration of Tin-Zinc electroplating completed	09/01/97
6. Established 100 gallon Al-Mn molten salt bath	09/01/97
7. Project Final Report due	03/31/98

PROJECT SUMMARY

PROJECT TITLE & ID: Aircraft Depainting Technology; PP-81

RESEARCH CATEGORY: 6.3 Advanced Development

LEAD AGENCY: U.S. Navy

LAB: Naval Air Warfare Center Aircraft Division - Patuxent River, MD

PRINCIPAL INVESTIGATOR: Mr. Joseph Kozol

FY 1997 FUNDS: $930K

OBJECTIVE: To develop non-hazardous replacements for chemical paint stripping use on Navy aircraft, weapon systems and support equipment. Current chemical paint strippers contain hazardous components (i.e., phenols, methylene chloride, and chromates) and depainting operations at maintenance depots are a major source of hazardous waste generation in the DoD. Federal and state agencies are restricting the use and disposal of these hazardous materials through the Clean Air and Water Acts, RCRA and local Air Quality Managment Districts. Service directives also require significant reductions in hazardous waste. Several generic alternative stripping methods to the present chemical removers are being developed that need to be optimized and evaluated for use at the Naval Aviation Depots.

TECHNICAL APPROACH AND RISKS: Alternative depainting methods must meet increasing environmental constraints; maintain aircraft (A/C) rework operations; and be versatile (handle higher strength structures (carrier landings) and different Navy coatings). Also, the harsh Navy operating environment can adversely affect aircraft structural integrity, further complicating process replacement efforts. This program will identify the best alternatives from existing/developmental methods such as non-hazardous chemical paint strippers (i.e. no chrome, MeC, etc.) and mechanical procedures (plastic media blasting (PMB), flash lamp, dry ice, waterjet, etc.). Procedure efficiency, substrate surface effects, hazardous waste generation and A/C applicability will be investigated in order to determine the best procedure for Navy applications. Comparison of each technique's advantages and disadvantages will also be performed. Mechanical procedures eliminate chemicals, but can damage substrate surfaces. Since some aircraft skins are very thin, this is not acceptable. However, combinations of some techniques (i.e. flash lamp/dry ice) could eliminate or minimize surface damage to an acceptable level. The flash lamp degrades the coating and the reduced pressure dry ice performs the final removal (no surface damage). The practical application of flashlamp/dry ice (Flashjet) will require the use of robotic assisted manipulation. Two manipulators are under investigation. The first is a mobile (vehicle integrated) semi-robotic system for depainting large aircraft. The second is a fixed gantry system for small aircraft and off-aircraft components.

ACCOMPLISHMENTS: In FY 1996, McDonnell Douglas completed a final report on the effects of flashjet stripping on graphite/epoxy composites. Construction of a mobile, semi-robotic system for depainting large aircraft is continuing.

BENEFIT: The elimination of the majority of chemical paint strippers would significantly reduce the total amount of hazardous materials generated by the Navy. Furthermore, requirements for emission control equipment for methylene chloride (estimated at $1M/facility) would be eliminated. This effort is particularly important considering the cost of these aircraft and equipment as well as the severely deleterious environment in which the Navy operates. This technology could also be transitioned to the commercial sector (aerospace, automotive, marine corps., etc.).

FY 1997 Milestones	Planned Date
1. Complete modifications to effluent capture system	01/01/97
2. Integration of CO_2 pelletizer completed	02/01/97
3. Complete modification to flashjet head system	03/01/97
4. Integration of flashjet with manipulator system completed	04/01/97
5. Initiate site installation study of flashjet gantry system	05/01/97
6. Software engineering modifications for manipulator integration completed	08/01/97
7. Checkout and demonstration of complete system at manufacturing site	10/01/97
8. Transport system to NADEP Jacksonville	11/01/97
9. Demonstration of flashjet process at NADEP Jacksonville	12/01/97
10. Final Report submitted	04/30/98

PROJECT SUMMARY

PROJECT TITLE & ID: Encapsulated Micron Fire Suppression Technology; PP-113

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: U.S. Air Force

LAB: Wright Laboratory - Tyndall Air Force Base, FL

PRINCIPAL INVESTIGATOR: Dr. Charles J. Kibert

FY 1997 FUNDS: $740K

OBJECTIVE: This project seeks to develop and test a new fire suppression concept leveraged on former Soviet aerosol technology for use in a wide variety of critical fire protection roles. The Air Force is faced with the difficult problem that existing fire suppression agents, while extremely effective at fire extinguishment, also create undesirable environmental impacts. Halons, while powerful fire suppressants, cause ozone depletion and are being eliminated. Halon 1301 replacement candidates identified thus far are 2-3 times less effective than Halon 1301 in fire suppression efficiency. Known replacement agents require major modifications to piping, nozzles, and other components of the delivery systems. Suitable replacements resulting from existing programs and technologies are not available or projected to be available in the near term. A class of environmentally safe agents that can fulfill some of these fire suppression roles is needed to maintain operational readiness. An aerosol suppressant, known as Encapsulated Micron Aerosol Agent (EMAA), may provide DoD with an environmentally and occupationally safe agent that has 6 times the fire suppression capability of Halon 1301 by weight. It requires no piping or pressure cylinders and will be a fraction of the cost of Halon 1301 in installation and life cycle costs. It also allows delivery strategies other than total flood and can be placed locally in high fire risk locations within a facility. This is an exploratory development project. Agent specifications and application data will be provided to AF Civil Engineer Support Agency and industry.

TECHNICAL APPROACH AND RISKS: Various EMAA formulations will be tested for fire suppression efficiency, materials compatibility, storage stability and lifetime, packaging, toxicity, electrical conductivity, corrosion, and combustion products. The analyses will be utilized in the engineering of delivery systems for both total-flood and local fire suppression strategies. Alternative delivery methods containing both non-electrical and electrical initiation will be designed, fabricated, and tested to determine the best practical methods for delivery. Ultimately, large scale testing against scenario fires will be conducted to determine the final configuration of EMAA delivery systems. Applications for EMAA will center around local delivery systems that can be used without the need of total flooding. The risk is moderate with major corrosion potential of the EMAA solids in a humid atmosphere, toxicological

effects of lung penetration of the micron and submicron sized particles, and the handling of high temperatures and energy developed in the creation of the aerosol.

ACCOMPLISHMENTS: Both total-flood and local fire suppression delivery strategies placed locally in high fire risk locations within a facility are possible. Preliminary results show that EMAA formulations using gelled aerosols are not as corrosive as pyrogenic aerosols.

BENEFIT: If successful, pyrotechnically generated aerosols will provide DoD with an option to replace Halon 1301 with non-ozone-depleting fire suppressants. EMAA will also provide superior performance on a weight and volume basis. The result will be new applications such as fire protection systems that can be easily built into deployable shelters, hand thrown and remotely launched devices that can be used to provide "first-aid" to begin the process of extinguishment, and the potential to protect large fuel storage tanks from destruction via compact fire suppression systems. DoD will receive royalties for products created and sold as a result of the research and development.

FY 1997 Milestones	Planned Date
1. Design and test electrostatic charging hardware	03/01/97
2. Complete testing of pyrogenic, gelled, and superfine silicon aerosols using electrostatic charging	06/01/97
3. Complete design and testing of electrostically charged aerosol system	09/01/97
4. Assessment of efficiency improvement due to electrostatic charging	10/01/97
5. Complete specifications on electronic hardware for electrostatic charging	12/01/97
6. Final Report	12/30/97

PROJECT SUMMARY

PROJECT TITLE & ID: Solid State Metal Cleaning; PP-116

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: U.S. Air Force

LAB: Wright Laboratory - Wright-Patterson Air Force Base, OH

PRINCIPAL INVESTIGATOR: Mr. Phil D. Mykytiuk

FY 1997 FUNDS: $560K

OBJECTIVE: There are two technical objectives to be achieved by this project: (1) to develop and transition to a DoD customer a cleaning process for large (and small) aircraft components that do not require the use of water or VOCs; and (2) to develop a process that will allow components to proceed directly to the next step in the process for surface cleaning without the need for subsequent treatments involving water or organic solvents. This project will transition into the AF ALCs with potential to be utilized at other service depots.

TECHNICAL APPROACH AND RISKS: Under this task, McDonnell-Douglas Aerospace-East (MDA-E) is analyzing CO_2 pellet blasting coupled with UV light and an activated oxygen technique to clean Al alloy. The CO_2/Ultraviolet (UV) Light Activated Oxygen cleaning technology is applicable to small- and medium-sized components which require a surface cleanliness suitable for bonding, and produces no collectible by-products other than the soil being removed. This cleaning approach combines two established cleaning methods into a single system, namely CO_2 pellet cleaning and ultraviolet light cleaning.

CO_2 pellet cleaning is an established technology which is currently being used at a number of DOD depots. This cleaning method is used to remove carbon and other soils from airframe and engine components prior to inspection and repair. However, the cleanliness level achieved is not sufficient for bonding operations. Ultraviolet light cleaning of organic contamination has been used primarily in the electronics industry for precision cleaning. However, UV light is only effective for cleaning thin film contamination. The current cleaning process combines these two technologies and applies them to metallic components which require cleaning prior to bonding or coating (metallic or organic coatings).

Laboratory testing (i.e. wet tape adhesion and salt spray), is being accomplished to define and measure surface cleanliness levels needed for various subsequent processing steps to maintain/improve the performance of subsequent operations. This effort is low risk.

ACCOMPLISHMENTS: In FY 1996, the optimization and verification of surface cleanliness processes were completed.

BENEFIT: The project benefits are improved worker safety, reduced environmental liability, reduced cost of storage, tracking, handling and disposal of hazardous waste, and uninterrupted production and repair of metal aircraft components.

FY 1997 Milestones	Planned Date
1. Complete process parameters, optimization, and economies of scale-up system	03/01/97
2. Complete scale-up of system	07/01/97
3. Complete bonding, plating and performance validation studies of scaled-up system	09/30/97
4. Final Report submitted	03/31/98

PROJECT SUMMARY

PROJECT TITLE & ID: Rapid Testing for Acceptable Materials and Processes; PP-117

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: U.S. Air Force

LAB: Wright Laboratory - Wright-Patterson Air Force Base, OH

PRINCIPAL INVESTIGATOR: Mr. Jim Mazza

FY 1996 COMPLETED PROJECT

OBJECTIVE: To develop low risk, fast-track methodologies and techniques for military qualification of new or modified, environmentally benign (low-VOC and non-chromated) adhesives, adhesive primer materials, and metal pre-bond surface preparations.

BENEFIT: An accelerated and less costly means for qualification testing of alternate, substitute, and emerging new materials and processes will allow rapid introduction of environmentally acceptable materials into the military inventory and force structure.

ACCOMPLISHMENTS: Combined environmental and reliability test techniques with a 20:1 time compression ratio were created for evaluating adhesive bond durability. Specimens fabricated for correlation with Navy exposure assessment are now being testing aboard USS Kittyhawk.

TRANSITION: Several potential end users reaffirmed their interest in the accelerated tests and provided specimens for testing. The testing techniques will be formalized through the American Society for Testing and Materials (ASTM) or other appropriate vehicle.

PROJECT SUMMARY

PROJECT TITLE & ID: Large Area Powder Coating; PP-121

RESEARCH CATEGORY: 6.3 Advanced Development

LEAD AGENCY: U.S. Air Force

LAB: Wright Laboratory - Wright-Patterson Air Force Base, OH

PRINCIPAL INVESTIGATOR: Mr. Michael Halliwell

FY 1997 FUNDS: $215K

OBJECTIVE: To provide powder materials and technology to improve aircraft coating performance and increase environmental acceptability. These powder materials will enable the minimization or elimination of Volatile Organic Compounds (VOC's) and Hazardous Air Pollutants (HAP's) used in manufacturing and coatings applications. Furthermore, the coatings will exhibit improved performance including improved durability, cleanability, impact resistance, solvent resistance, mar resistance, corrosion resistance, and enhanced appearance. The materials and technology will be incorporated into various low/zero VOC coating systems under development by the Air Force and industry. The project will transition to the Air Logistics Centers through the Coatings Technology Integration Office, Wright-Patterson Air Force Base OH.

TECHNICAL APPROACH AND RISKS: The approach is to focus on the formulation, development, optimization, and production of powder materials that will provide reduction in VOC's and HAP's, and the desired improvements in overall coating system performance. Characterization of current and newly developed materials will be undertaken to determine the causes of performance limitations and avenues to improved performance. Material research and development will include one or more of the following: (1) Crosslinkable Resin Powders. These are polymeric powders that are sprayable with a High Velocity Thermal Spray (HVTS) application process. The physical properties of the resultant coatings are greatly enhanced by incorporating crosslinking mechanisms. This gives better solvent resistance and rain erosion durability. Very high performance thermoplastic materials will also be considered; (2) Pigmented Polymer Beads; (3) Microballoon based pigments; and (4) Hollow fibrillar pigments. These pigments have shown to greatly enhance the properties of coatings while reducing the VOC's required for application. The powder materials will be formulated in low and zero VOC coatings. The performance of the coatings will be evaluated using selected state-of-the-art analytical tools and methods already set in place. These tools will enable fast and accurate feedback which will minimize development and transition time. This effort is part of an integrated program to develop alternatives to current high solvent coating systems for aircraft. Additional work will be incorporated into an already established Integrated Product Team (IPT). Most promising technologies will be

developed, optimized, scaled-up, demonstrated and qualified. Needs of customers, including Air Logistics Centers (ALCs) and MAJCOMs are given priority attention. This program is coordinated with Wright Laboratory's continuing work on advanced low/zero VOC programs and integral to their Aircraft Coating Strategy.

ACCOMPLISHMENTS: In FY 1996, functional surrogate crosslinking powders have been successfully sprayed.

BENEFIT: The research and development will lead to low or zero VOC coatings that will be easier to clean, have a more uniform appearance, and will be less susceptible to weathering effects. As a result, repainting and touch up requirements will be reduced, thereby producing significant life-cycle cost savings. The effort is also applicable to the commercial aircraft and automotive industries.

FY 1997 Milestones		Planned Date
1.	Complete evaluation of SOTA failure mechanism by characterization techniques	02/28/97
2.	Award contract for formulation of powder materials R&D	03/31/97
3.	Supply initial formulated powder coatings for HVTS and D/C spraying	07/31/97
4.	Characterization of formulated coatings for optimization	08/31/97
5.	Supply optimized formula	09/30/97
6.	Demonstrate field application with formulated powder materials in low VOC coatings	09/30/97
7.	Final Report submitted	03/31/98

PROJECT SUMMARY

PROJECT TITLE & ID: Non-Chemical Surface Preparation; PP-130

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: U.S. Air Force

LAB: Wright Laboratory - Wright-Patterson Air Force Base, OH

PRINCIPAL INVESTIGATOR: Mr. Jim Mazza

FY 1996 COMPLETED PROJECT

OBJECTIVE: To identify, develop, and optimize non-wet chemistry approaches for the formation of stable morphologies on the surface of aluminum, titanium and copper materials that will allow high quality coating and adhesive bonding.

BENEFIT: Elimination or minimization of hazardous materials such as hexavalent chromium, oxidizing acids and concentrated bases used in conventional cleaning and surface preparation processes.

ACCOMPLISHMENTS: Both plasma spray and sol-gel deposition were investigated. Plasma sprayed coatings did not yield long-term moisture durability as desired for aluminum bonding. However, coatings for titanium bonding were more promising. Results using sol-gel coatings for both aluminum and titanium preparation prior to adhesive bonding were very encouraging. Strength data and long-term moisture durability were comparable to state-of-the-art controls.

TRANSITION: It is likely that the aluminum treatment will be adopted by at least one commercial user in 1997.

PROJECT SUMMARY

PROJECT TITLE & ID: Laser Cleaning and Coatings Removal; PP-139

RESEARCH CATEGORY: 6.3 Advanced Development

LEAD AGENCY: U.S. Air Force

LAB: Wright Laboratory - Wright-Patterson Air Force Base, OH

PRINCIPAL INVESTIGATOR: Mr. Michael Waddell

FY 1997 FUNDS: $1,090K

OBJECTIVE: The objective of this effort is to provide a field demonstration of a prototype laser-based facility to demonstrate environmentally acceptable and cost competitive cleaning and coatings removal from weapon system components. The project will deliver a working production prototype to a DoD aircraft depot facility for extended applications demonstrations. This project will accomplish the following objectives:

a. Design a self-contained cleaning and coating removal system
b. Design a waste product collection system
c. Complete preliminary systems engineering
d. Design will be approved by engineering, EPA, and OSHA

TECHNICAL APPROACH AND RISKS: This effort will implement the technical approach determined in the FY 93 preliminary design. It will also expand the preliminary design to a detailed final design. Additionally, this program will fabricate, evaluate, develop, and demonstrate a state-of-the-art automated, controllable coating removal and cleaning system (a repair or remanufacturing cell or process). Various aircraft media controls, robotics sensors, and instrumentation are currently available commercially and may be applied to the system. Software will have to be developed/modified to control the production system. Systems design must incorporate all applicable safety devices and features. The risks with this assessment are associated with availability and adequacy of Air Force, Navy, Army, and industry data. The system will maneuver the laser beam around complex geometries whether on manual or automatic control modes. All effluent gases and particulates will be treated and/or captured. Once the system is built, it will undergo a rigorous confirmation test scheme.

ACCOMPLISHMENTS: In FY 1996 this project has developed a laser-based prototype system to demonstrate environmentally acceptable and cost-competitive cleaning and coatings removal from weapon system components.

BENEFIT: Will demonstrate a laser-based coating removal and cleaning process for a wide range of aircraft components having different sizes and materials. The long-term benefits include eliminating toxins and hazardous wastes currently generated by DoD and industry in upkeep, overhaul, and remanufacture operations. The recommended process is expected to be highly cost effective by eliminating the present and future air, solid, and water polluting methods. Thus, it will reduce or eliminate the costs for hazardous stripping of materials, reduce containment costs for solid, liquid and vapor waste streams, and eliminate the legal liabilities associated with waste disposal.

FY 1997 Milestones		Planned Date
1.	Select first use site	11/30/96
2.	Procure/Build Sub-System	
2.1 2.a.	Gantry Robot	03/31/97
2.2 2.b.	Beam Delivery system	02/28/97
2.3 2.c.	CO_2 Laser	08/31/97
2.4 2.d.	High Speed Scanners	06/30/97
2.5 2.e.	Spectral Sensor System	07/31/97
2.6 2.f.	Workcell Enclosure	06/30/97
2.7 2.g.	Scanner Vac System	08/31/97
2.8 2.h.	Workcell Airflow System	08/31/97
3.	Checkout and Debug of Individual Sub-Systems	09/30/97
4.	Begin Integration of Sub-Systems	03/31/97
5.	Begin Integration System Debug and Checkout	09/30/97
6.	Begin System Testing	09/30/97

PROJECT SUMMARY

PROJECT TITLE & ID: Advanced Fire Fighting Streaming Agent; PP-158

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: U.S. Air Force

LAB: Wright Laboratory - Tyndall Air Force Base, FL

PRINCIPAL INVESTIGATOR: Dr. Charles Kibert

FY 1997 FUNDS: $950K

OBJECTIVE: This project seeks to identify, evaluate, and validate environmentally and occupationally safe streaming agents that are drop-in replacements for Halon 1211 in wheeled 150 lb. flightline fire extinguishers, in aircraft portable fire extinguishers, and in facility portables. Programs to find a replacement for Halon 1211 were initially directed at chemicals that were available in production quantities. Research indicated that even the most powerful replacements available in these quantities would require 2 to 3 times as much agent as Halon 1211 to extinguish a fire. The best agent from among this group, perfluorohexane, had restrictions placed on it in the EPA Significant New Alternatives Policy (SNAP) listing because of its long atmospheric lifetime. Because of this restriction and an Air Force Civil Engineering/Logistics (CE/LG) re-validation of the requirement for a clean streaming agent, a program to explore several promising families of laboratory scale chemicals was initiated. The Air Force, as Project Reliance lead agency for streaming agent development, has received support for this approach from the Navy and Army. This is an exploratory development project which will transition to 6.3 advanced development.

TECHNICAL APPROACH AND RISKS: Agents from several promising chemical families will be synthesized, then subjected to several key tests to determine their overall suitability: fire suppression effectiveness, limit testing for lethality, storage stability, materials compatibility and global environmental impacts. The agents are expected to emerge from one of four families of chemicals: tropodegradable halocarbon, phosphonitrilics, silicon compounds, or organometallics. As work progresses, additional chemical families will be considered for screening. At each stage of the screening process, failure to meet a given criterion will eliminate a compound from further consideration. Compounds that successfully negotiate the screening will be further tested to determine their lethality and cardiotoxicity levels for use in obtaining EPA approval. Medium scale fire suppression effectiveness will be determined along with initial delivery system parameters. QSAR, tissue uptake studies, and pharmokinetic modeling will be initiated. Pilot plant studies to assess large scale synthesis methods will be accomplished. It is expected that 2 to 5 agents may survive the initial screening and testing. These will be subjected to large scale testing by teams of seasoned Air Force/Navy/Marine Corps firefighters against a variety of two and three dimensional

scenario fires. Firefighter exposure data and combustion product interaction information will be analyzed to insure that the compound(s) selected meet both military and EPA requirements. The risks for this effort is moderate. It is known that some of the chemicals proposed for testing are 10 to 100 times more powerful as fire suppressants than the Halons with the major unknown being the toxicity of these materials. Consequently, rapid assessment of the toxicity of these substances will be a priority.

ACCOMPLISHMENTS: In FY 1996, the project completed synthesis of phosphorus compounds, organometallic compounds and initiated synthesis of silane compound.

BENEFIT: The successful development of an Advanced Fire Fighting Streaming Agent would have great benefits for the Army and Navy as well as the Air Force. The phaseout of Ozone Depleting Chemicals (ODCs) has threatened the ability of the military to provide a powerful, clean means of suppressing fires previously afforded by Halon 1211. The replacements originally developed as substitutes for Halon 1211 have all been caveated for greenhouse warming potential or ozone depletion by the EPA. The Advanced Streaming Agent will be developed from chemical families which have none of these negative global environmental impacts. In addition to the military, the civilian sector, particularly aircraft companies, have had essentially the same problem as the military with regard to the phaseout of Halon 1211. This is a technology that has dual use potential and will serve the needs of multiple sectors of the civilian fire fighting community.

FY 1997 Milestones	Planned Date
1. Synthesize silanes and siloxane compounds	03/03/97
2. Cup burner and range testing of silanes and siloxanes	05/01/97
3. Complete assessment of tropodegradable halocarbons	08/01/97
4. Determination of top candidates for final testing	10/01/97
5. Propose streaming agent candidates for advanced development	12/01/97

PROJECT SUMMARY

PROJECT TITLE & ID: Use of Biomass Technologies on Military Installations; PP-227

RESEARCH CATEGORY: 6.3 Advanced Development

LEAD AGENCY: Environmental Protection Agency

LAB: National Risk Management Research Laboratory - Research Triangle Park, NC

PRINCIPAL INVESTIGATOR: Dr. Carol R. Purvis

FY 1996 COMPLETED PROJECT

OBJECTIVE: To demonstrate that small, innovative, energy conversion technologies fueled with biomass are technically, economically, and environmentally feasible for DoD installations, industries, and developing countries.

BENEFIT: Systems fueled with biomass (e.g., scrap wood and downed trees) do not emit SO_2, produce zero net gain of CO_2, reduce air toxic emissions, and help solve waste disposal problems. This project provided the impetus needed for the design and development of small systems, and creation of markets.

ACCOMPLISHMENT: Final design and equipment selections were made during FY 1996 and construction was initiated at US Marine Corp Base, Camp Lejeune, NC.

TRANSITION: The final demonstration of this innovative system is planned during calendar year 1997.

PROJECT SUMMARY

PROJECT TITLE & ID: Life Cycle Engineering & Design Program; PP-304

RESEARCH CATEGORY: 6.3 Advanced Development

LEAD AGENCY: Environmental Protection Agency

LAB: National Risk Management Research Laboratory - Cincinatti, OH

PRINCIPAL INVESTIGATOR: Mr. Kenneth R. Stone

FY 1997 FUNDS: $300K

OBJECTIVE: The objective is to take lessons learned from DoD cases and other industrial operations Life Cycle Assessments (LCAs) being funded by EPA to generate a design guide for implementing life cycle principles on environment, performance and cost as an aid to decision-making. This project applies LCA principles to selected DoD operations in order to identify and test potential technical solutions to reduce reliance on toxic chemicals and solvents in industrial and DoD operations.

The National Risk Management Research Laboratory (NRMRL) has tested several solvent formulations as possible alternatives for MEK and methylene chloride in aircraft radome and fuselage depainting. Technology demonstrations with the Army showed the potential for significant real reductions in the quantity of chemical agent resistant coating (CARC) paint needed to coat military vehicles, and demonstrated the fact that painting operations in the field can vary significantly among installations. A life cycle inventory (LCI) with the Navy and DOE identified environmental effects of selected energetic materials a step in improving design.

TECHNICAL APPROACH AND RISKS: With the completing of the base LCAs and technology evaluations for the alternative chemical depainting and the chemical agent resistant coating (CARC) projects, our next step is to conduct an examination of the impacts of these operations on a more detailed level in order to assess the health, ecological, and resource depletion aspects of the alternatives. Two impact assessments are planned: one on CARC painting operations and the second on alternative chemical depainting. In the CARC project, we discovered that a painting procedure in the field can vary significantly, depending upon the installations practices. This impact assessment will give us a good comparative basis to test the application of the methodology to distinct, specific sites, providing key information on the validity of our approach. In the case of the depainting study, significant issues have arisen regarding the impacts from the production of constituents, specifically propylene carbonate, n-methyl-pyrrolidone and more recently, benzyl alcohol. The impact assessment will focus on these chemicals as components of a solvent formulation, identifying life cycle impacts and documenting the information as a

basis for comparison. Another component of the Life Cycle Engineering and Design (LCED) Program is the integration of cost/benefit tools with the LCA methodology. EPA began this component of the study this year as an EPA funded effort to lay the groundwork for the methodology and submit it for peer review. It will be tested in selected federal operations and will be a component of the final report for the LCED program in 1998. To enhance technology transfer, a lessons learned document will be generated with a full presentation of difficulties and successes experienced to date.

ACCOMPLISHMENTS: A Data Quality Assurance Plan for DoD-wide Chemical Agent Resistant Coating (CARC) painting operations was completed and approved in FY 1996.

BENEFIT: The anticipated benefits include the elimination of an EPA 17 chemical, MEK, from the radome depainting process, along with VOC emissions. While CARC undergoes tests and reformulation to reduce VOC content, this project shall generate guidance with applicability to facility CARC painting operations DoD-wide. Techniques and product improvements will generate cost savings and operational efficiency. Ultimately, the product of this work will be a guidance document, or model, for conducting LCAs of DoD and related industrial operations in order to improve design and process efficiencies. This document will demonstrate the experiences of the research team and offer a streamlined approach that reduces the cost of conducting an LCA.

FY 1997 Milestones	Planned Date
1. Develop Workplan	12/15/96
2. Evaluate Cost Tools for Integration	01/30/97
3. Initiate Impact Assessments	03/30/97
4. Publish Lessons Learned Compendium	04/20/97
5. Complete GBU-24 Energetics LCI and Data Module	04/20/97
6. Complete Impact Assessment of NMP and PC	07/31/97
7. Complete Impact Assessment of CARC	08/15/97
8. Develop Prototype Cost Methodology for LCA	08/31/97
9. Complete Solvents and CARC-related Ecoprofiles	09/30/97

PROJECT SUMMARY

PROJECT TITLE & ID: Non-Ozone Depleting Refrigerants for Navy Chillers; PP-309

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: Environmental Protection Agency

LAB: National Risk Management Research Laboratory - Research Triangle Park, NC

PRINCIPAL INVESTIGATOR: Mr. William J. Rhodes

FY 1996 COMPLETED PROJECT

OBJECTIVE: To aid the Navy, by conducting toxicity tests, in selecting a non-ozone-depleting, retrofittable refrigerant to replace CFC-114 in existing shipboard chillers.

BENEFIT: A retrofittable, drop-in, non-ozone-depleting substance (non-ODS) alternative HFC-236 fa for CFC-114 has been identified and will avoid significant capital expenditure on chiller replacement. For about 850 shipboard chiller units subject to replacement, an estimated savings of about $500 million is expected.

ACCOMPLISHMENTS: HFC-236ea and fa, both non-ODSs which exhibit acceptable thermodynamic and engineering properties, were evaluated as replacements for CFC-114. Animal toxicity and cardiac sensitization tests were conducted. Navy selected HFC-236fa to replace CFC-114 in the chiller units.

TRANSITION: The Navy's replacement program will begin with one chiller retrofit in 1997 followed by fleet conversions starting in 1998. Also, the EPA has listed HFC-236fa in its Significant New Alternatives Policy (SNAP) program.

PROJECT SUMMARY

PROJECT TITLE & ID: Reduce VOCs and HAPs from Painting and Cleaning Operations; PP-316

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: Environmental Protection Agency

LAB: National Risk Management Research Laboratory - Research Triangle Park, NC

PRINCIPAL INVESTIGATOR:: Mr. Charles H. Darvin

FY 1996 COMPLETED PROJECT

OBJECTIVE: To demonstrate the ability of the recirculation/partitioning concept to reduce exhaust volumes from spray booths during painting operations at DoD maintenance depots.

BENEFIT: Reduction in VOCs released as toxic air emissions during painting operations at maintenance depots.

ACCOMPLISHMENTS: During demonstration, exhaust volume reduction of 60 percent and greater was achieved and validated while keeping the booth environment within safety codes.

TRANSITION: This control technology for painting operations is being successfully transitioned to the US Marine Corp Logistic Center, Barstow, CA.

PROJECT SUMMARY

PROJECT TITLE & ID: Integrated Expert Solvent Substitution Data Base; PP-331

RESEARCH CATEGORY: 6.3 Advanced Development

LEAD AGENCY: Environmental Protection Agency

LAB: Office of Environmental Engineering & Technology Demonstration - Washington, D.C.

PRINCIPAL INVESTIGATOR: Mr. Myles Morse

FY 1997 FUNDS: $460K

OBJECTIVE: The Enviroene (ES) project creates a federal pollution prevention network and solvent alternatives umbrella by integrating technical information and networks from other federal agencies. ES will assist DoD and supporting industries with easy access to information on available substitutes to meet the ODS and toxics reductions under the Clean Air Act, and EO 12856. The Expert Solvent Alternatives Data Base referred to as the solvent umbrella, will allow users to access solvent alternative information through a single easy to use command structure which will seamlessly access and retrieve information from as many as 16 component federal state and private data bases. The Solvent Umbrella will utilize state of the art electronic navigation, translation, and search tools in the Internet environment. The search architecture will allow information to be synthesized and weighted specific to user's process needs. The project will add new alternatives to the umbrella based on ongoing work in existing test bed centers. The project will include targeted training for DoD. The umbrella will give users access to solvent alternatives based on their specific process needs, and will reduce redundant requirements testing.

TECHNICAL APPROACH AND RISKS: The technical approach to this project includes the development of an interactive WWW platform; evaluation, grouping, and conversion of priority solvent data base tools; and the development of an architecture that will access various data base formats and synthesize the data base information based on the users process needs. The project will include the following: a) Modify search engine to access all component data bases; b) Complete data base conversions for phase 1 and 2 data bases; c) Sequentially add phase 1 and 2 data bases to ES multiple query; d) Develop decision trees for queries at process specific levels; e) Develop an expert architecture for seamless access to the umbrella data bases with weighted query synthesis; f) Integrate decision trees into the expert architecture; g) Review other DoD/federal/private data bases; h) Conduct global searches for umbrella expansion; i) Deploy system to DoD, other federal agencies and industry. Conversion of data bases to universal extraction languages may impact schedule. Data variation may effect synthesis function.

ACCOMPLISHMENTS: The first prototype of context-based decision tree query of the solvent umbrella architecture has been developed and the field evaluation of phase I architecture has been completed.

BENEFIT: The benefits of this effort for DoD, DOE, and EPA include better centralized access to pertinent information to reduce the use of toxic and ozone depleting solvents; and a reduction of redundant research efforts. The benefits to industry include easier access to technical information that will allow them implement alternative and reduce the emissions of ODS and other toxics; and assist in meeting the bans under the Clean Air Act. Industrial benefits include monetary savings and liability reduction due to implementing P2 alternatives

FY 1997 Milestones	Planned Date
1. Add initial update of new information to HSSDS component through test bed centers	11/01/96
2. Activate phase 1 expert architecture capable of linking all data base categories with synthesis function	12/01/96
3. Complete phase 1 source characterization and data collection for umbrella expansion (does not include data base addition)	12/30/96
4. Complete phase 1 evaluation of other DoD data bases	12/30/96
5. Complete phase 1 decision trees through workgroup interface	03/01/97
6. Complete phase 1 data base conversion and linkage to umbrella	03/01/97
7. Complete field test and evaluation of version 1 architecture	05/01/97
8. Integrate phase 1 decision trees with weighted query search	06/01/97
9. Complete relational reporting function	07/01/97
10. Complete integration architecture with decision tree and search engine	08/01/97
11. Link with regulatory guidance umbrella	09/01/97
12. Final Report due	03/31/98

PROJECT SUMMARY

PROJECT TITLE & ID: Acid Recycle; PP-422

RESEARCH CATEGORY: 6.3 Advanced Development

LEAD AGENCY: Department of Energy

LAB: Los Alamos National Laboratory - Los Alamos, NM

PRINCIPAL INVESTIGATOR: Dr. Thomas Mills

FY 1997 FUNDS: $180K

OBJECTIVE: Demonstrate removal of nitric and hydrochloric (HCl) acids from radioactive liquid waste streams to levels meeting or exceeding federal and state regulations on liquid effluents. This will require at least 99 percent recycle of nitric and hydrochloric acid from waste solutions. Recycle acid will be reconcentrated sufficiently to be used for dissolutions, etc. in lieu of makeup acid. The project will develop, construct, and test process systems.

Existing effluent streams from the Los Alamos National Laboratory (LANL) Plutonium Facility to the Waste Treatment Facility contain 1-6 molar concentrations of nitric or hydrochloric acid, along with other dissolved nitrates or chlorides, and also contain small amounts of dissolved actinides. These nitrates and chlorides exiting the Plutonium Facility represent the primary source of these ions for the Waste Treatment Facility to handle. Following treatment, effluent liquids from the Waste Treatment Facility still contain nitrate and chloride concentrations in excess of the National Pollutant Discharge Elimination System (NPDES) limits of 45 ppm nitrate and 250 ppm chloride.

TECHNICAL APPROACH AND RISKS: This work will demonstrate nitric and hydrochloric acid recycle from actual plutonium processing waste solutions using two operations: (1) evaporation of acid and water from a solution containing radionuclides and inorganic salts and (2) separation of water and acid in evaporator product to generate concentrated acid. Acids will be separated from the radioactive component of the waste solution by evaporation. Nonvolatile radioactive residue will be sent to disposal or may receive further treatment (e.g., thermal denitration, electrodialysis, molten salt distillation) before disposal. Evaporated acid will be reconcentrated to a reusable state by fractional distillation or gas-phase membrane separation. Project develops integrated processes using semi-continuous operation consisting of evaporators followed by a distillation column or a membrane unit. DOE will fund development of the nitric acid distillation column.

While evaporation and fractional distillation have not been applied to recycle of plutonium waste solutions as integrated processes, much industrial production of nitric and hydrochloric acids uses this approach. Membrane separation applied to hydrochloric acid

reconcentration represents a new application of this technology. Membrane separation has been proven from a feasibility standpoint, but engineering problems of materials and limits of separating ability require development. Evaporative crystallization has been used routinely in chemical processes. Development and demonstration work is required to characterize process operation for the particular chloride salts in a crystallizing evaporator.

ACCOMPLISHMENTS: In FY 1996, crystals were continuously separated in a bench-scale crystallizing evaporator from solutions with a complex mixture of salts. A pilot-scale crystallizing evaporator has been designed and is being constructed.

BENEFIT: This research and development will enable continued operation of the LANL Plutonium Facility by meeting or exceeding increasingly stringent environmental regulation on liquid effluents. Costs of treating present waste acid streams will be greatly reduced. Direct cost savings are difficult to estimate, but the annual cost of all work in connection with the Plutonium Facility is in excess of $70M. If environmental objectives cannot be met, the Facility will not be permitted to operate. Amounts of TRU radioactive waste for eventual disposal will be reduced (yielding cost savings), and the waste forms will have greater chemical stability. Production of clean effluent waste streams may allow elimination construction of a pretreatment room at the proposed new Radioactive Liquid Waste Treatment Facility at LANL.

FY 1997 Milestones	Planned Date
1. Membrane design modifications complete	11/01/96
2. Crystallizer control system designed and tested	01/01/97
3. Modified membrane unit built	02/01/97
4. Membrane experiments complete	07/01/97
5. Final tests of crystallizing evaporator complete	07/01/97
6. 2-stage recycle system demonstrated	09/01/97
7. Final Report on HCl recycle	09/01/97

PROJECT SUMMARY

PROJECT TITLE & ID: High-Performance, Lead-Free Electrical Sealants; PP-429

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: Department of Energy

LAB: Sandia National Laboratory - Albuquerque, NM

PRINCIPAL INVESTIGATOR: Dr. John A. Emerson

FY 1997 FUNDS: $340K

OBJECTIVE: A lead-free material that replaces the high-performance, electrical-grade, fuel-resistant polysulfide sealant currently used for electrical components in aircraft (MIL-S-8516F) needs to be identified, characterized, and developed. The polysulfide sealant MIL-S-8516F, now in use, contains lead oxide. A lead-free "drop-in" replacement for MIL-S-8516F will help the Pollution Prevention SERDP Thrust Area achieve its objective of reducing the use of lead, a hazardous material that will be subjected to strict Environmental Protection Agency (EPA) regulations. Work will also be performed to see if toluene sealant solvents, also targeted by the EPA, can be replaced with nonhazardous solvents. Nonhazardous replacements for toluene solvents also directly support the Pollution Prevention SERDP Thrust Area. Through this work, new material qualification procedures for the nonhazardous sealant will be developed, material parameters for viscosity control will be introduced, and a method of material fingerprinting (which will permit tracking of lots from the supplier to government applications) will be developed. The ultimate objective of the project is to transfer the technology developed by identifying, characterizing, and developing appropriate nonhazardous material substitutes for MIL-S-8516F to both aerospace and DOE-integrated suppliers, contractors, and repair depots.

TECHNICAL APPROACH AND RISKS: Efforts in 1996 completed the development of a viscosity envelope for evaluating the flow of both the lead-containing polysulfide and alternative materials such as lead-free polysulfides and alternative materials. The understanding of sealant rheology is important to ensure that the alternative sealants can fill narrow channels and gaps. In 1997, the viscosity envelope concept will be introduced into the rewrite of MIL-S-8516 to replace a complicated test procedure. For stability of the formulated production material, better material characterization will continue to determine improved shelf life, particularly for field repairs, and better fuel resistance. Also for 1997, we will continue our work on better material and process characterization information that will be used in rewriting or issuing of a new specification. The major effort during 1997 will be the approval of the two material specifications and qualified vendors list. This effort will complete the program.

The major technical challenge in this project was identification of suitable lead-free formulations that are being developed into electrical-grade sealants capable of meeting the stringent requirements of MIL-S-8516F. These formulations are identified. Further product testing and development, specification writing, and commercial source development will be of the 1997 effort.

ACCOMPLISHMENTS: Efforts in FY 1996 completed the development of a viscosity envelope for evaluating the flow of both the lead-containing polysulfide and alternative materials. The understanding of sealant rheology is important to ensure that the alternative sealants can fill narrow channels and gaps.

BENEFIT: This project will cooperate with the appropriate government agencies and vendors to develop an environmentally responsible, drop-in material that will provide solutions to two major concerns:

- Limited Availability. Because of stricter requirements resulting from hazardous waste minimization, lead-containing (8516 type) polysulfides will become difficult or nearly impossible to acquire in the next few years. Also, vendors are finding it difficult to obtain the proper grade of the lead peroxide curative required for 8516 type sealants. If no substitute is found, mission readiness of aircraft and weapons systems would be lessened.

- Cradle-to-Grave Product Responsibility. Suppliers may have to assume cradle-to-grave responsibilities for materials such as the MIL-S-8516F sealant. If no lead-free substitute is found, these cradle-to-grave responsibilities could increase sealant costs considerably.

FY 1997 Milestones	Planned Date
1. Complete MIL-S-8516	09/01/97
2. Complete AMS Specification	10/01/97
3. Complete vendor qualification	11/30/97
4. Complete program documentation	12/15/97
5. Wrap up program	12/31/97

PROJECT SUMMARY

PROJECT TITLE & ID: Capacitive Deionization for Elimination of Wastes; PP-436

RESEARCH CATEGORY: 6.3 Advanced Development

LEAD AGENCY: Department of Energy

LAB: Lawrence Livermore National Laboratory - Livermore, CA

PRINCIPAL INVESTIGATOR: Dr. Joseph Farmer

FY 1996 COMPLETED PROJECT

OBJECTIVE: To provide detailed documentation for the carbon aerogel capacitative deionization (CDI) process which has been developed as a non-polluting, energy-efficient, and cost-effective alternative to ion exchange, reverse osmosis, electrodialysis, and evaporation for wastewater treatment and water purification.

BENEFIT: Elimination of secondary wastes associated with the chemical regeneration of ion exchange columns. Elimination of costly and troublesome membranes and high-pressure pumps. Reduction in energy consumption. Low-cost desalination of brackish water for reclamation. This process offers dramatic advantages in terms of both waste minimization and processing cost to DoD and DOE.

ACCOMPLISHMENTS: This project has resulted in a US Patent for CDI and a licensing agreement has been developed. CDI process was awarded R&D 100 award in 1995.

TRANSITION: This technology is being commercialized through a licensing agreement with private vendor.

PROJECT SUMMARY

PROJECT TITLE & ID: PVD Coatings and Ion Beam Processing as Alternatives to Electroplating; PP-632

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: U.S. Army

LAB: Army Research Laboratory - Aberdeen Proving Ground, MD

PRINCIPAL INVESTIGATOR: Dr. John H. Beatty

FY 1996 COMPLETED PROJECT

OBJECTIVE: Conduct applied research and development to demonstrate that metal or ceramic coatings deposited by physical vapor deposition (PVD) or by ion-beam-modified surfaces might be cost-effective, equivalent or superior performance, and environmentally acceptable alternatives to electroplated chromium and cadmium.

BENEFIT: Elimination or reduced usage of environmentally harmful chromium and cadmium electroplating processes. Also, improved performance compared to electroplated coatings would reducing the frequency of rework.

ACCOMPLISHMENTS: Coating of a main landing drag beam for the AH-64 Apache was successfully demonstrated using physical vapor deposition technology.

TRANSITION: This project has transitioned to the DoD Environmental Security Technology Certification Program (ESTCP) for full-scale demonstration and validation.

PROJECT SUMMARY

PROJECT TITLE & ID: Advanced Polyelectrolyte-Modified Zinc Phosphate Conversion Coatings; PP-659

RESEARCH CATEGORY: 6.3 Advanced Development

LEAD AGENCY: U.S. Army

LAB: Tank Automotive Command Research, Development, & Engineering Center - Warren, MI

PRINCIPAL INVESTIGATOR: Mr. Carl Handsy

FY 1996 COMPLETED PROJECT

OBJECTIVE: To demonstrate improved corrosion resistance of steels and adhesion to polymeric top-coats without the use of hexavalent chromium, nickel and cobalt, which are used as activators in the rinse solutions of zinc phosphate (ZnPhos) conversion coatings.

BENEFIT: A five percent improvement in the life of ferrous metal components coated with improved zinc phosphate pretreatment is anticipated. Savings to DoD as a result of diminished corrosion is estimated to be $2-3 Billion per year.

ACCOMPLISHMENTS: Polyacrylic acid (PAA), an anionic polyelectrolyte species, was evaluated as replacement for the conventional chromium-containing compounds. The PAA-rinsed ZnPhos coatings not only displayed excellent salt spray resistance but also contributed to strong electrochemical affinity of electrodeposited polymer top-coatings.

TRANSITION: The process will be transferred to a private industrial coating applicator company for pilot plant demonstrations in a manufacturing plant and at the DoD National Defense Center for Environmental Excellence (NDCEE).

PROJECT SUMMARY

PROJECT TITLE & ID: Extraction & Recycling of LOVA Propellants Using Supercritical Fluids; PP-660

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: U.S. Army

LAB: Army Research Laboratory - Aberdeen Proving Ground, MD

PRINCIPAL INVESTIGATOR: Dr. Jeffrey B. Morris

FY 1996 COMPLETED PROJECT

OBJECTIVE: To demonstrate the utility of Supercritical Fluid (SCF) extraction for the recovery of RDX from Composition B explosive formulation.

BENEFIT: Solid gun propellants and explosives are currently destroyed by open burning/open detonation, or incineration. Recycling using SCF would have both economic and environmental advantages over destruction.

ACCOMPLISHMENTS: Supercritical CO_2 was effective in removing the TNT and wax from Composition B. The remaining material from this separation process was RDX, which displayed low solubility. However, using CO_2 and ethane as processing solvents, the supercritical fluid extraction (SFE) process was ineffective for the recovery of RDX from Composition A-3.

TRANSITION: A patent disclosure on this RDX recovery process has been submitted for review by the Army Research Laboratory (ARL). A CRADA was established between commercial vendor and the ARL for further development.

PROJECT SUMMARY

PROJECT TITLE & ID: Chemistry of Halon Substitutes; PP-666

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: U.S. Army

LAB: Army Research Laboratory - Aberdeen Proving Ground, MD

PRINCIPAL INVESTIGATOR: Mr. Anthony Finnerty

FY 1996 COMPLETED PROJECT

OBJECTIVE: To investigate the principal mechanism (heat absorbing versus chemical) of fire suppression agents.

BENEFIT: Understanding the fire suppression mechanism is an important factor in predicting the effectiveness of a fire suppression agent and the production of toxic byproducts.

ACCOMPLISHMENTS: To assess efficiency, the cost, space, and weight claims of agents were considered. Optical and Scanning microscopy have been used to study partical size and degree of agglomeration of non-toxic powder fire extinguishing agents. The agents which are considered most efficient show small particle sizes, tight size distributions and little or no agglomeration.

TRANSITION: The accomplishments and results of this project have been transitioned to the Next Generation Fire Suppression Technology Program (NGFSTP) for continued development.

PROJECT SUMMARY

PROJECT TITLE & ID: Non-Chromate Conversion Coatings for Aluminum Alloys; PP-673

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: U.S. Army

LAB: Army Research Laboratory - Aberdeen Proving Ground, MD

PRINCIPAL INVESTIGATOR: Dr. John H. Beatty

FY 1996 COMPLETED PROJECT

OBJECTIVE: To develop a non-chromate conversion coating for aluminum alloys, and an alternative sealing treatment, which were anticipated to be compatible.

BENEFIT: Replacement of the sodium dichromate currently used in the anodizing process for combat and tactical vehicles, munitions, and aircraft.

ACCOMPLISHMENTS: Cyclic salt spray testing was conducted to simulate outdoor exposure. All the non-chromate conversion coatings performed well on aluminum alloys 7039 and 5083, which shows promise for future implementation on a variety of Army systems, although, for the 2000 series, the performance and reproducibility of non-chromate conversion is not currently acceptable.

TRANSITION: This effort leveraged work being performed by the National Center for Manufacturing Sciences (NCMS) on similar coatings on aluminum alloys, and transitions to the US Army Armament Research, Development, and Engineering Center (ARDEC) for implementation.

PROJECT SUMMARY

PROJECT TITLE & ID: Non Ozone Depleting Sealants for Ammunition Applications; PP-674

RESEARCH CATEGORY: 6.3 Advanced Development

LEAD AGENCY: U.S. Army

LAB: Army Armament Research, Development, and Engineering Center - Picatinny Arsenal, NJ

PRINCIPAL INVESTIGATOR: Mr. Dean Martinelli

FY 1996 COMPLETED PROJECT

OBJECTIVE: Replacement of the Army's existing case-mouth waterproofing sealant (MIL-C-13783) which contains methyl chloroform (1,1,1 trichloroethane) as the primary solvent.

BENEFIT: Replacement would allow continued compliance with the Clean Air Act Amendments of 1990 which mandated a ban on production of methyl chloroform (and all other Class I ODSs) for non-essential operations by January 1996.

ACCOMPLISHMENTS: Various off-the-shelf alternatives were evaluated. A water-borne, styrene/acrylic modified asphaltic material with filler was selected to replace the currently used sealant in small caliber ammunition. Modified sealant applicators were fabricated.

TRANSITION: The alternative, water-borne material will be implemented into production of all small caliber ammunition at Lake City Army Ammunition Plant starting January 1998.

PROJECT SUMMARY

PROJECT TITLE & ID: Laser Ignition to Replace Chemical Ordnance Igniters for Propulsion; PP-680

RESEARCH CATEGORY: 6.1 Basic Research

LEAD AGENCY: U.S. Army

LAB: Army Research Laboratory - Aberdeen Proving Ground, MD

PRINCIPAL INVESTIGATOR: Dr. Brad Forch

FY 1997 FUNDS: $180K

OBJECTIVE: The laser is a non-polluting ignition source that can replace thousands of pounds of hazardous materials in the life cycle of a single armament system. The objective is to eliminate hazardous components in ordnance (including ordnance manufacturing); to reduce the production of waste and unnecessary energetic materials in manufacturing for propulsion systems which includes large, medium and small caliber guns, rockets and missiles; to eliminate inventories of lead containing primers (lead styphnate and lead azide); and to eliminate hazards in storage and disposal of these components. The long-term goal is to develop a Universal Laser Ignition System for propulsion that is free from lead and other hazardous and polluting chemicals.

TECHNICAL APPROACH AND RISKS: The technical approach involved in this work is to perform fundamental research on the interaction of energetic materials with intense laser radiation to achieve reliable and reproducible ignition. Fundamental research is then transitioned (in house) to design and fabricate a small scale prototype laser-based ignition system. This prototype ignition system is then transitioned from small scale to a large scale prototype igniter. The large scale igniter is then tested on an armament /propulsion system and demonstrated. The overall process is recycled (back in the laboratory and through the demonstration process) to make performance improvements. Finally the ignition system is demonstrated to the user and Program or Product Manager. We foresee no major technical risks in our approach at present. ARL and its partners are uniquely qualified to pursue the research. No one else, anywhere else has the compliment of fundamental research equipment and applied research capabilities.

ACCOMPLISHMENTS: SERDP support in FY 1996 led to the laser being selected as the main igniter for PM-CRUSADER Self-Propelled Howitzer (155 mm XM297 cannon) which is the largest developmental program in the Army.

BENEFIT: The laser is non-polluting and lead containing igniters are eliminated. Hazardous components in ordnance and ordnance manufacturing are eliminated. A universal igniter for

propulsion systems is envisioned. The laser igniter replaces technology that is over 100 years old. The technology provides a safer system for soldiers in the field and numerous performance benefits which include higher firing rates, reduced hazard from accidental ignition from electromagnetic radiation, full computer control of the laser and thus the ignition event, and another completed link in the digital battlefield. Results are directly transferable to the Army, Navy, Air Force, PM-Crusader, PM-Paladin, PM-Apache, PM-Bradley, and Light Forces.

FY 1997 Milestones	Planned Date
1. Receive new 30 mm laser, test in laboratory	11/01/96
2. Receive new designed flexible bolt fiber optic cable	11/15/96
3. Complete energy threshold expts for new 30 mm igniter materials	12/01/96
4. Test new metal window seals (concial preforms) in G fixture at Benet Labs	12/15/96
5. Modification of LRS300 lasers completed and tested for rate-of-fire Thermal Management test	12/15/96
6. Obtain final results of neutron beam scatter experiments of sapphire window structure	12/30/96
7. Test CRDA and SBIR breech-mounted lasers in lab	01/15/97
8. Design new optical focusing element for breech-mounted lasers	01/15/97
9. Test fire breech-mounted lasers on 155 mm	01/30/97
10. 30 mm rapid fire test using new laser (procured under ARL mission funding)	01/30/97
11. Support Thermal Management Testing of XM297 155 mm cannon at Yuma Proving Grounds	02/01/97
12. Complete testing of Nd:YAG vs CO_2 laser for ignition of energetic materials	03/30/97
13. Complete preliminary design of diode laser igniter	04/15/97

PROJECT SUMMARY

PROJECT TITLE & ID: Chemical and Physical Processes Responsible for Flame Inhibition Using Halon Agents and Their Alternatives; PP-682

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: U.S. Army

LAB: Army Research Laboratory - Aberdeen Proving Ground, MD

PRINCIPAL INVESTIGATOR: Dr. Andrzej W. Miziolek

FY 1996 COMPLETED PROJECT

OBJECTIVE: To develop a detailed flame chemistry computer model to predict the relative flame extinguishment properties of new Halon-alternative compounds, as well as to identify the possible formation of toxic flame products resulting from the use of these agents.

BENEFIT: This model, once fully verified, will become a very important predictive and cost saving tool for the RDT&E survivability laboratories for screening new compounds, or mixtures of compounds, and for interpreting results of full-scale testing.

ACCOMPLISHMENTS: The near-infrared tunable diode laser (TDL) was demonstrated for hydrogen fluoride (HF) detection during full-scale fire suppression testing, and HF profiles were completed for methane/air inhibited by Halon 1301.

TRANSITION: The accomplishments and results of this project have been transitioned to the Next Generation Fire Suppression Technology Program (NGFSTP) for continued development.

PROJECT SUMMARY

PROJECT TITLE & ID: Recycling Propellants in Nonpolluting Supercritical Fluids: Novel Computational Chemistry Models For Predicting Effective Solvents; PP-695

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: U.S. Army

LAB: Army Research Laboratory - Aberdeen Proving Ground, MD

PRINCIPAL INVESTIGATOR: Dr. Betsy Rice

FY 1997 FUNDS: $200K

OBJECTIVE: Waste solid explosives and gun propellants are destroyed primarily by open pit burning or incineration; extraction and recycling of the propellant using a non-polluting, inert supercritical fluid (SCF) solvent such as CO_2 has economic and environmental advantages. Although the ingredients in composite (nitramine based) propellants are insoluble in CO_2, solubility is enhanced when trace amounts of simple polar modifiers are added to the SCF solvent. The objective of this project is to determine the optimal physical conditions and chemical makeup of an effective SCF CO_2 solvent with added polar modifier using well-established computational chemistry techniques. The technology developed in this project will have application to nitramine-based explosive and propellant formulations.

TECHNICAL APPROACH AND RISKS: Two complementary theoretical investigations on properties and effectiveness of polar modified -CO_2 SCF solvents will be pursued in parallel. The first investigation will focus on the actual dynamic event for dissolution of an RDX crystal in an SCF solvent. Solvation dependence on the physical conditions of the system (far from or close to the critical point of the SCF) will be examined. The second investigation focuses on determining modifier properties that enhance solubility of RDX in the SCF solvent, using rigorous quantum mechanical methods.

ACCOMPLISHMENTS: During FY 1996, SCF extraction studies, previously conducted on RDX explosives on a RDX model, were applied to other cyclic nitramines. Their transferability to other DOD explosives of interest (CL20 and HMX) is being evaluated.

BENEFIT: Prevention of pollution associated with disposal of Army (and Navy) explosives and gun propellants; associated reduction of life-cost of munitions. Recycling is an alternative to current open burning of gun propellants, which is increasingly restricted, and to incineration, which is not widely available and requires size reduction preprocessing.

FY 1997 Milestones	Planned Date
1. Finish CO_2-CO_2 SAPT dimer interactions	12/01/96
2. Complete fit of analytic function (to be used in simulations) of CO_2-CO_2 SAPT dimer interactions	12/01/96
3. Complete MP2-level minimizations to determine local minima for DMNA/CH_3CN	03/01/97
4. Complete MP2-level minimizations to determine local minima for DMNA/CH_3CN	03/01/97
5. Complete development of classical interaction potentials for nitranmine + CO_2 + CH_3CN	07/01/97
6. Complete molecular dynamics calculations for solid RDX + solution. This could be done for different modifiers	08/01/97

PROJECT SUMMARY

PROJECT TITLE & ID: Fluorinated Ship-Hull Coatings for Non-Polluting Fouling Control; PP-756

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: U.S. Navy

LAB: Naval Command Control and Ocean Surveillance Center - San Diego, CA

PRINCIPAL INVESTIGATOR: Mr. Mike Putnam

FY 1997 FUNDS: $565K

OBJECTIVE: The overall goal of this project is to develop non-polluting, easy fouling release, hull coatings based on flexible, low surface-energy polymers. Ship hull protection from marine fouling organisms is essential for efficient fleet operation and energy conservation. Presently, the Navy standard antifouling coating contains copper as a toxicant. The copper leaching from these coatings represents an environmental hazard and is the subject of increasing regulation which will impact normal fleet operations.

TECHNICAL APPROACH AND RISKS: This approach takes advantage of weak adhesion of an adherent to materials that have low surface free energy. Fouling organisms employ a number of mechanisms for adhesion to solid surfaces. However, the lower the surface energy of the solid, the weaker is the adhesive bond. Previous research has shown that coating flexibility and other parameters are also important to achieving easy fouling-release. Our approach to generating the ideal surface involves binding perfluorinated side chains onto a polymeric backbone to create a comb type polymer with the desired physical and chemical parameters. Candidate backbone structures include acrylate based copolymers polymerized from varying ratios of acrylate/methacrylate monomers, silicone polyether-urethanes, and silicone network systems. The critical technical issues are: (1) fixing the surface orientation of the molecules and fluorinated side-chains and (2) the degree of polymer flexibility which can be achieved without sacrificing toughness/durability.

ACCOMPLISHMENTS: Work is ongoing to improve the polymer to produce coatings with lower adhesion of marine organisms than commercially-available silicones which use a toxic tin-based catalyst. Systems based on acrylic copolymers are also being investigated.

BENEFIT: A non-polluting, easily cleaned coating will be synthesized which will contain no leachable toxics. Instead, this new coating will have a non-wetting, low-energy surface which resists attachment of marine fouling organisms and permits easy removal of fouling which does adhere. These coatings will benefit all operated vessels and structures with obvious commercial application.

FY 1997 Milestones	Planned Date
1. Initiate field exposure testing of RTV11 with optimized, high performance non-tin catalyst (NRL)	11/01/96
2. Begin correlation of fouling performance with surface properties and characterization of acrylate polymers, identify prime polymer series and "best" polymer (NRaD)	11/01/96
3. Complete systematic surface characterization of acrylate coatings (NRaD)	11/01/96
4. Initiate evaluation of non-tin catalyst for 7-Fox-fluoro-oxetane sol-gel networks (NRL)	11/01/96
5. Initiate atomic force microscopy (AFM) evaluation of sol-gel coating structure/performance (NRL)	12/01/96
6. Scale-up RTV11 optimized-tin and non-tin catalyst to coat 8x10 panels for field exposure (NRL)	01/01/97
7. Complete large scale synthesis of best acrylate polymer (NRaD)	02/01/97
8. Begin F-14 and F-17 fluoro-oxetane coating synthesis; optimize fluoro-organo-TREOS compatibilizer and catalyst (NRL)	03/01/97
9. Correlate AFM results on water aging of RTV11 coatings (tin/non tin catalysts) for optimization (NRL)	03/01/97
10. Transition new catalyst RTV11 results to NRL 6.3 and industry (NRL)	06/01/97
11. Correlate long/short term exposure studies with surface and physical properties of acrylate polymers/coatings (NRaD)	08/01/97
12. Complete long term exposure study of "best" acrylate polymer (NRaD)	08/01/97
13. Begin F-14 and/or F-17 fluoro oxetane coating full panel testing (NRL)	09/01/97
14. Optimize large-scale coating application parameters for transition of "best" acrylate polymer coating to dem/val (multiple-year performance evaluation/testing) (NRaD)	09/01/97

PROJECT SUMMARY

PROJECT TITLE & ID: Solventless Pyrotechnic Manufacturing; PP-757

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: U.S. Navy

LAB: Naval Surface Warfare Center - Crane, IN

PRINCIPAL INVESTIGATOR: Dr. Norris Caldwell

FY 1997 FUNDS: $200K

OBJECTIVE: The objective of the project is to demonstrate the application of cast/cure methodology to eliminate the (solvent) hazardous waste and associated VOC emissions in some important areas of military pyrotechnics manufacture. The cast/cure approach to manufacture offers the potential for the virtual elimination of the use of volative solvents (VOC's) in pyrotechnics processing, whilst still producing the material in a manner that mitigates hazards (ignition) sensitivity.

TECHNICAL APPROACH AND RISKS: The project will use modern liquid/curable polymeric binder materials to formulate pyrotechnic compositions. Tasks that are significant hurdles for the successful completion of this project include the installation of mixing equipment and development of operational procedures. These tasks are on-going. Other major tasks inlcude laboratory scale formulating, functional testing, scale-up, and performance testing. In a sense, the cast/cure methodology is mature technology since it has been used for some time to process solid rocket motor propellant materials. Therefore, the main risk involved in this effort is not whether cast/cure processing is a viable technology, but whether products formulated for this type of processing, and so produced, will meet established and developing requirements for in-service pyrotechnic products. This effort emphasizes the very important air-countermeasures applications of pyrotechnics.

ACCOMPLISHMENTS: In FY 1996, this project continued the laboratory work on commercial energetic: GAP-based and non energetic [HTPB-based (grey body)] composition materials.

BENEFIT: Due to the elimination of hazardous solvent waste and the potential for VOC emissions, expensive solvent recovery and recyling systems would not be needed, and the costs of waste stream treatment would be eliminated. The potential payoff is exemplified by some (projected) procurement figures for FY 95: DOD is planning to procure quantities of decoy flares corresponding to a total of about 650,000 pounds of pyrotechnic material, generating from 195,000 to 975,000 gallons of hazardous waste solvent. Based on

representative current costs of disposing of waste solvent, annual cost savings from solvent waste elimination alone could be from $2.1M to $10.6M.

	FY 1997 Milestones	Planned Date
1.	Scale up (to full grain size) conventional material (MTV) replacement	03/1/97
1.1	Process approval	03/1/97
1.2	Produce full size test grain, assemble	03/1/97
1.3	Ground-based function (countermeasures) testing	03/1/97
2.	Scale up (to full grain size) improved special pyrotechnic material based on GAP energetic polymer	09/1/97
2.1	Process approval	09/1/97
2.2	Produce full size test grain, assemble	09/1/97
2.3	Ground-based function (countermeasures) testing	09/1/97

PROJECT SUMMARY

PROJECT TITLE & ID: Solventless Manufacture of Artillery Propellant Using Thermoplastic Elastomer Binder; PP-867

RESEARCH CATEGORY: 6.3 Advanced Development

LEAD AGENCY: U.S. Navy

LAB: Naval Air Warfare Center - China Lake, CA

PRINCIPAL INVESTIGATOR: Dr. Thomas Stephens

FY 1997 FUNDS: $300K

OBJECTIVE: The objective is to demonstrate the feasibility of reducing or eliminating the emission of volatile organic compounds (VOCs) and solvents associated with the production of gun propellants by using thermoplastic elastomer (TPE) propellants. New propellant formulations that reduce or eliminate the use of solvents will be developed and evaluated for replacement of current propellants that require solvents to manufacture. Multi-base gun propellant for artillery ammunition creates 0.3 lb of solvent emissions per lb of propellant, and at expected production rates of 3 million lb/yr, this represents the largest source of VOC emissions due to gun propellant production. This project will demonstrate at a pilot plant scale the production of TPE gun propellant by using solventless continuous processing. For leveraging cost of testing and evaluation this project will be closely coordinated with efforts to develop a propellant charge for the Crusader 155-mm howitzer, and data on new propellants developed under this project will be provided to the Program Executive Officer for Field Artillery Systems in order for the PEO to choose a new solventless propellant formulation to fully develop and qualify for field use.

TECHNICAL APPROACH AND RISKS: New TPE propellant formulations will be designed to permit solventless processing while simultaneously meeting performance and safety requirements. This will require evaluating the most promising TPEs, determining the proper composition and molecular weight of the TPE, and optimizing the choice and amount of oxidizer in the propellant. A solventless manufacturing process will be developed for this propellant by modifying and adapting existing continuous twin screw extrusion technology. Manufacture of the new TPE propellant by the solventless process will be demonstrated at a pilot plant scale. The manufacturability, safety, sensitivity and performance properties of the propellant produced will be evaluated in "proof of principle" tests. The main technical risk is that meeting several propellant material property requirements simultaneously may be difficult. In particular, howitzer ammunition requires specific performance characteristics over a wide range of firing temperatures, pressures, and charge loadings, and TPE-based propellants have not been evaluated for a wide range of conditions.

In FY 1997, TPEs will be characterized for viscosity and other physical properties for optimizing binder composition. Small scale (1 to 5 kg) propellant mixes will be prepared and evaluated for solventless processability in initial processing studies that will include capillary viscometry and batch extrusion runs. Viscosity data will be used in numerical simulations of the flow of propellant through the extrusion die. These die modeling calculations will be used in FY 1998 to optimize the die design to ensure stable flow and accurate dimensions of the extruded propellant. Initial feeder studies will begin to evaluate methods for handling raw materials and feeding them to the continuous processor. These initial processing studies are required before processing the propellant in the twin screw continuous processor in FY 1998.

ACCOMPLISHMENTS: An initial composition of Hytrel TPE has been selected as a binder for the gun propellant based on thermochemical calculations and mixing tests.

BENEFIT: Solventless propellant processing technology developed under this project will be transferable to other gun propellant programs. Risk associated with this new technology will be reduced to a level acceptable to program managers without further demonstrations. Once the technology is fully developed and implemented, solvent emissions due to triple-base gun propellant manufacture can be eliminated, including approximately 500,000 lb/yr VOC emissions, 400,000 lb/yr other solvent emissions (contaminated with explosives), elimination of scrap propellant (by reworking propellant in the manufacturing process), cost saving in VOC elimination facility modifications, and elimination of the costs of solvents and of energy costs in heating drying houses.

FY 1997 Milestones	Planned Date
1. Propellant safety and sensitivity tests complete	06/01/97
2. Initial processability studies complete	07/01/97
3. Initial extrusion die modeling complete	09/01/97
4. Initial feeder studies complete	09/01/97

PROJECT SUMMARY

PROJECT TITLE & ID: Trapped Vortex Combustor for Gas Turbine Engines; PP-1042

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: U.S. Air Force

LAB: Wright Laboratory - Wright-Patterson Air Force Base, OH

PRINCIPAL INVESTIGATOR: Dr. W. M. Roquemore

FY 1997 FUNDS: $500K

OBJECTIVE: The goals of this project are to demonstrate the feasibility of developing a Trapped Vortex (TV) combustor that will: 1) reduce aircraft pollutant emissions (NOx, VOCs, CO, and PM-10) by 60 percent, bringing them significantly below the proposed 1996 EPA regulations, and 2) reduce NOx emissions by 60 percent, bringing them below the 1995 EPA regulation for L&M based gas turbine engines burning distillate fuels. Since the total amount of emissions from gas turbine engines is directly proportional to the amount of fuel consumed, a 3 percent savings in fuel will also result in a 3 percent reduction in emissions. Since aircraft spend most of their time at high altitudes, a 3 percent reduction in total emissions would reduce global environmental changes due to NOx reduction of ozone in the stratosphere and the greenhouse effect of CO_2 and H_2O emitted from high flying aircraft.

TECHNICAL APPROACH AND RISKS: The project will develop an optimized trapped vortex design for use in the General Electric Integrated High Performance Turbine Engine Technology (IHPTET) Phase III prototype gas turbine engine and will evaluate the use of a trapped vortex combustor for reducing NOx emissions in stationary gas turbine engines used on-board Naval vessels for power generation. Three parts are required to make this new combustor system: a new integrated fuel injector/diffuser, TV combustor section and thermal management system. General Electric (GE) in conjunction with the IHPTET program will design and test the integrated diffuser and thermal management system. GE and Wright Laboratory will work together on this SERDP project to design and incorporate the low emissions TV combustor portion and will incorporate all three efforts into a final design. The technical approach uses a combined Computational Fluid Dynamics (CFD) design study with an experimental sector rig study to investigate different TV configuration at realistic conditions and with realistic size combustors. TV combustors with three different missions will be investigated. The first mission corresponds to a future high performance aircraft that would utilize Integrated High Performance Turbine Engine Technology (IHPTET) engine technology. The second mission corresponds to that of a conventional aircraft. This mission is included to provide the Air Force with the option of upgrading existing engines to a low emissions, fuel efficient TV combustor in the future. The third mission corresponds to possible future forward-fit for new purchases of LM2500 engines used aboard Naval vessels.

ACCOMPLISHMENTS: In FY 1996, the project completed the atmospheric test facility checked out for combustion testing and completed cold flow velocity measurements characterizing the velocity pattern in the wake of the diffuser and splitters.

BENEFIT: This project will provide the basis to demonstrate the capability of TV combustors to reduce pollutant emissions and conserve fuel. The environmental objective is to reduce NOx, VOCs, CO, and PM-10 aircraft emissions to 60 percent below the proposed 1996 EPA aircraft emissions regulations and to reduce NOx emissions by 60 percent below the California Resource Board recommendation of 42 ppm for L&M based gas turbine engines burning distillate fuels. The environmental impact of only military aircraft using the TV technology that meets the project goals would be enormous. For example, assume that all existing military aircraft had a TV combustor. The VOCs for the Air Force and Naval bases would drop by a factor of 10 in some cases and the NOx emissions would be reduced by 20 percent to 40 percent depending on the aircraft at the bases. This would permit flight operations and training to continue at current levels with reduced or even eliminated fines due to pollutant emissions from aircraft. If commercial aircraft also had TV combustors, then the environmental and cost impact improves by a factor of 8, since in the US commercial aircraft uses about 88 percent of the jet fuel consumed annually.

FY 1997 Milestones	Planned Date
1. Complete test of aircraft TVC #1 sector	11/01/96
2. Complete CFD studies of aircraft TVC #1	01/01/97
3. Transition TVC desgin information IHPTET build no. 1	01/01/97
4. Design aircraft TVC #2	03/01/97
5. Fabricate aircraft TVC #2	05/01/97
6. Test of aircraft TVC #2 completed	10/01/97

PROJECT SUMMARY

PROJECT TITLE & ID: Pesticide Reduction through Precision Targeting; PP-1053

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: Department of Agriculture

LAB: Imported Fire Ant & Household Insects Research Unit - Gainesville, FL

PRINCIPAL INVESTIGATOR: Dr. Richard Brenner

FY 1997 FUNDS: $380K

OBJECTIVE: DoD presently uses approximately 1 million lbs of pesticide active ingredient annually, excluding pesticides used during major deployments. In each of these settings, these pests and disease vectors also affect the health of DoD personnel by transmitting pathogens, contaminating foods and surfaces with biologics, and producing allergens. The overall research goal is to reduce pesticide use and risks through the use of precision targeting and comparative risk reduction. This will result in the development of a comprehensive, standardized, verifiable, and documentable system for protecting troops, DoD supplies, and DoD facilities from disease vectors and pests in a manner that reduces pesticide use and risk. This novel precision targeting approach to integrated pest management (IPM) will reduce pollution from pesticides while ensuring control of disease vectors and pests that impact military readiness in three major settings: (1) In military deployments and training exercises, vector-borne diseases, such as malaria, leishmaniasis, dengue, and tick borne illnesses transmitted by mosquitoes, flies, and ticks, cause direct loss in troop combat effectiveness. (2) In the DoD supply system and in DoD supply depots, stored products pests and other pests cause losses to war stocks of military rations and other material such as uniforms and blankets. Losses are increased due to long storage times. (3) On military installations, a wide range of pest species cause damage to buildings, structures, and vegetation.

TECHNICAL APPROACH AND RISKS: This research is designed to meet these unique DoD needs by providing sophisticated surveillance of disease vectors and pests combined with a novel process of "precision targeting" selected interventions. Precision targeting is a functional strategy allowing incorporation of independent IPM tools. However, additional research is needed to develop the precision targeting concept further into a standardized, quantifiable risk assessment computer program for determining the necessity of interventions and selection of those that will optimize reduced use of pesticides, risk reductions, and cost effectiveness (comparative risk reduction).

Project research will focus largely on developing a comparative risk assessment model based on spatial probabilities that incorporate techniques of monitoring and detecting pests and

risks, and on proving the concept and process for versatile field-use by relatively untrained personnel. Few technical difficulties should be encountered because the project's research team has diverse expertise that is capable of executing this complex mix of basic and applied research, in part due to existing USDA funding. This project leverages existing scientific expertise within USDA Center for Medical, Agricultural, and Veterinary Entomology (7-9 scientists) with technical support and equipment made possible through the SERDP funding to address this important unique DoD issue of preventing pollution while safeguarding supplies, facilities, and personnel from disease vectors and pests.

ACCOMPLISHMENTS: Begun in FY 1996, the accomplishments include: development of standardized monitoring procedures for cockroach and ant pests; a field kit for insecticide resistance detection; a comparative risk assessment algorithm; and standardized documentation procedures.

BENEFIT: Successful execution of this research will, for the first time, provide standardized procedures for achieving comparative risk reductions associated with the broad scope of disease vectors, pests, pesticides, and pesticide resistant populations in military theaters of operation as well as on military installations. Following successful development and testing of this concept, full documentation will be presented to the Armed Forces Pest Management Board for possible expansion to other pests and DoD operations, thereby resulting in the greatest possible reduction in pesticide use. Specific payoffs include: reduced use of pesticides by as much as 40-80 percent depending on pest problem via a comprehensive, standardized, verifiable, and documentable system; reduced direct and indirect costs of pesticides.

	FY 1997 Milestones	Planned Date
1.	Select GIS interface of choice to match predominant/priority systems in DoD	12/30/96
1.1	Complete adjustment of output code of spatial statistics/comparative risk assessments to GIS code of choice	03/30/97
2.	Develop scheme and prototype prioritization matrix for structures and grounds of a presentative DoD facility; initiate pilot study for all representative pests	04/30/97
3.	Determine standardized monitoring procedures for representative mosquito (*Aedes* spp.)	06/30/97
4.	Determine structure of program shell for Comparative Risk Reduction Module	08/30/97
4.1	Incorporate EPA's Integrated Risk Information System (IRIS) into Comparative Risk Reduction module	09/30/97

PROJECT SUMMARY

PROJECT TITLE & ID: Low VOC Chemical Agent Resistant Coatings (CARC); PP-1056

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: U.S. Army

LAB: Army Armament Research, Development, and Engineering Center - Picatinny Arsenal, NJ

PRINCIPAL INVESTIGATOR: Mr. Robert Katz

FY 1997 FUNDS: $500K

OBJECTIVE: This project will develop a low VOC CARC system suitable for use on military equipment by DoD in which the materials and processes for the reformulation/application, stripping and disposal are optimized and in compliance with current and anticipated regulatory requirements. The primary focus is to reduce the VOC of the polyurethane topcoat from 3.5lb/gal to 1.8lb/gal. A secondary objective will be to eliminate the hazardous air pollutants (HAPs) and toxic solvents used in the current topcoat formulation.

TECHNICAL APPROACH AND RISKS: The technical approach for the reformulation work will focus on high performance, water reducible (WR) polyurethane binder systems which have the potential for chemical agent resistance and meets the performance requirements of the Army, Air Force and Marine Corps. Candidate polymers will be obtained from raw material suppliers, screened for live agent resistance, and formulated into camouflage topcoats. Requirements for the WR CARC will include compatibility with current camouflage pattern painting procedures and universal use under all current and foreseen VOC regulations.

The approach to the stripping work will be to focus on evaluation of currently used methods of removal to optimize the processes for de-painting and disposal of the CARC developed under this project. A review will be made of current technology including those projects conducted by: the National Defense Center for Environmental Excellence (NDCEE), the Joint Depot Environmental Panel (JDEP), the three services under the SERDP; as well as a review of existing CARC stripping operations at depots, orginal equipment suppliers and other manufacturing/maintenance facilities. Selected technologies will then be tested to determine the applicability to strip the new CARC as applied to a variety of substrates (aluminum, steel, composites). Processes will be adjusted to permit the optimum utilization of technologies to minimize environmental impacts of the stripping and disposal operations consistent with economical operations at the manufacturing and maintenance facilities. Emphasis will be given to non-chemical means of stripping due to the large quantities of hazardous wastes which are generated by the use of chemicals.

ACCOMPLISHMENTS: This is a FY 1997 New Start.

BENEFIT: At current annual usage nationwide, estimated to be 3.0 million gallons per year, a CARC targeted to a 1.8lb/gal VOC limit would save at least 5 million pounds of VOC per year in the application of the coating, proportionately reduce photochemical smog generation and avert Notices of Violation (NOV) at user facilities including depots, air logistic centers (ALC), bases and original equipment manufacturers. Those VOCs which would be reduced or eliminated include: methyl isobutyl ketone, methyl isoamyl ketone, toluene, xylene and butyl acetate, all of which are hazardous air pollutants (HAPs).

Furthermore, the technology developed by this project will eliminate the need to install emission control devices for approximately twelve facilities for a total cost avoidance of $60 million for equipment installation and $3 million saved in annual operating costs. By developing one CARC topcoat for use by all the services substantial savings will result in procurement and logistics operations.

FY 1997 Milestones	Planned Date
1. Establish low VOC formulation providing chemical agent resistance	03/01/97
2. Begin preparing test plan for application studies	06/01/97
3. Begin preparing test plan for stripping studies	06/01/97
4. Initiate application studies	07/01/97
5. Initiate stripping studies	07/01/97
6. Complete validation of coating properties of pigmented system	09/01/97

PROJECT SUMMARY

PROJECT TITLE & ID: Eliminate Toxic and VOC Constitutents from Small Caliber Ammunition; PP-1057

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: U.S. Army

LAB: Army Armament Research, Development, and Engineering Center - Picatinny Arsenal, NJ

PRINCIPAL INVESTIGATOR: Mr. Wade Bunting

FY 1997 FUNDS: $500K

OBJECTIVE: The objective of this program is to develop non-toxic small caliber ammunition which will meet U.S. and NATO performance standards for all calibers (5.56mm, 7.62mm, 9mm, .50 caliber). This effort will focus on eliminating toxic components in the projectile core, primer, and manufacturing processes. All porposed solutions must be economical and feasible while meeting all environmental regulatory guidelines and standards over the life cycle of the cartridge.

TECHNICAL APPROACH AND RISKS: Projectile core: The approach is to conduct the appropriate environmental studies of candidate projectile core materials to ensure their viability for use in non-toxic projectiles, and provide methods by which the recovery of the material is optimized and release is minimized. Environmental testing will include leaching, corrosion, and biological uptake studies to determine the form chemistry, mobility, and uptake of unrecoverable materials. These results will provide guidance for optimizing the environmental stability and thus maximizing recovery and recyclability of the next generation of projectile materials.

The milestone "Decision Point - NDI effort": This milestone refers to the on-going program sponsored by the U.S. Army Environmental Center (AEC) which is examining the use of non-developmental materials to replace the lead cores in small arms projectiles. The initial phase of this effort will be completed at the end of the 1st Qtr FY 1997.

The major areas of concern for projectile core replacement are the terminal ballistic performance (lethality/penetration) and mobility/toxicity of materials. In addition, the final candidate must also conform to all bio-uptake requirements.

Cartridge primer: This effort will utilize a new class of non-toxic energetic materials called Metastable Interstitial Composites (MICs) as a replacement for current primer materials which include lead styphnate, barium nitrate, and antimony sulfide. A MIC material is an

engineered energetic consisting of two or more chemical species that are exothermically reactive with each other. There are three areas of concern for replacement of current primer materials. First, the MIC compounds have never been used in small arms percussion primers. Second, the temperature output from the MIC composition upon ignition must be verified. Third, performance of these materials when subjected to high rates of fire such as in a minigun, must be investigated.

ACCOMPLISHMENTS: This is a FY 1997 New Start.

BENEFIT: This project will develop a non-toxic cartridge that will eliminate the environmental and hazardous effects that are associated with current ammunition. It is anticipated that approximately $2.5 million required for waste removal at each outdoor firing range as well as the $100 K annual cost for lead contamination monitoring will be eliminated. Furthermore, the 601 indoor National Guard ranges currently closed will no longer require $150 K in upgrades to become operational and saving $90 million. LCAAP yearly costs will be reduced by $100 K per year from elimination of lead sludge treatment.

	FY 1997 Milestones	Planned Date
1.	Initiate characterization of chemistry and morphology of spent, non-lead prototype projectiles. (Obtained from AEC NDI grain bullet demonstration)	02/03/97
2.	Begin identification and selection of environment to which new compounds will be exposed.	02/03/97
3.	Begin optimization of MIC primer materials for Energy Release and Impact Sensitivity.	02/03/97
4.	Decision Point - NDI effort	03/03/97
5.	Initiate characterization of effects of moisture and temperature on ignition sensitivity.	05/01/97
6.	Initiate exposure and leaching experiments for projectile core materials.	06/02/97
7.	Begin second iteration of optimization of MIC primer composition.	08/04/97
8.	Establish draft test plan and performance parameters.	09/30/97

PROJECT SUMMARY

PROJECT TITLE & ID: Elimination of Toxic Materials and Solvents from Solid Propellant Components; PP-1058

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: U.S. Army

LAB: Missile Command - Huntsville, AL

PRINCIPAL INVESTIGATOR: Dr. William Stephens

FY 1997 FUNDS: $500K

OBJECTIVE: The overall goal of the "Green Missile" program is the elimination of major sources of toxic/hazardous materials used in solid rocket propulsion systems. The objectives are three-fold: 1) develop lead-free extrudable and castable propellant for minimum smoke systems; 2) develop complete and clean, HCl-free, combustion of propellant; and 3) develop solventless methods for processing energetic oxidizers.

TECHNICAL APPROACH AND RISKS: Extrudable and castable formulations of ADN, CL-20, or AN, rocket motor propellants will be developed. The associated energetic polymeric binders, including thermoplasic elastomers (TPE) developed by the CAME program, will also be evaluated and selected for development with the candidate formulations. Data from the characterization of the final formulations shall be compared to baseline data to determine the amount of pollution prevention obtained using the new formulation and that the user requirements are still being met. Technology demonstrations will be done for the Tri-Service 2.75 and Army's HELLFIRE systems.

Propellant formulations containing ultra-fine aluminum (UFAL) and non-halogenated oxidizers will be developed and characterized. Formulation studies shall be conducted to determine the optimum processing procedures. The combustion efficiency shall be determined as well as the identity of the combustion products to demonstrate clean burning.

A method to produce comminuted ADN, CL-20, and AN oxidizers in a size, shape, and purity suitable for propellant manufacture will be developed. Process parameters that influence the behavior of these solvated oxidizers, when crystallized in a liquefied gas antisolvent, will be evaluated and optimized. Included in these evaluations will be the effects of atomization droplet size, nozzle configuration, oxidizer concentration, solution viscosity, and liquid surface tension on particle size and structure. Process scale-up will be demonstrated with materials to be used for the 2.75 and HELLFIRE systems. Supercritical fluid processing of energetic components will be achieved through supercritical chemistry,

supercritical processing and energetic material processing. Technology demonstrations will be done with ADN/CL-20.

The technical risk associated with the research is that the alternative materials that are developed may be environmentally friendly but not have the necessary propulsion characteristics. Critical factors include particle size, bonding agent compatibility, and stability.

ACCOMPLISHMENTS: This is a FY 1997 New Start.

BENEFIT: Immediate benefits from the research are: 1) a lead-free formulation for HELLFIRE and the Tri-Service 2.75 rocket, solving 95 percent of the current lead emission problems; 2) an HCl-free formulation for the TITAN, solving 25 percent of the total HCl emissions; and 3) a solventless energetic oxidizer process for HELLFIRE, a solution for 60 percent of the ADN/CL-20 systems.

With technology transfer to similar systems, the potential overall cost savings from the research are $1.5M from lead elimination and $3M with solvent elimination/minimization.

	FY 1997 Milestones	Planned Date
1.	Elimination of lead	
1.1	Alternatives identified	04/15/97
1.2	Evaluation of alternatives completed	10/15/97
2.	Clean Oxidizer Processing	
2.1.	Process testing completed	05/15/97
2.2	Solventless physical-chemical characterization completed	11/15/97

PROJECT SUMMARY

PROJECT TITLE & ID: Next Generation Replacement for Halon 1301 for Weapon Systems; PP-1059

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: National Institute of Standards and Technology

LAB: Building and Fire Research Laboratory - Gathersburg, MD

PRINCIPAL INVESTIGATOR: Dr. Richard Gann

FY 1997 FUNDS: $1,300K

OBJECTIVE: Halon 1301, the predominant and critical total flooding fire suppressant installed in weapons systems, is no longer in production due to its deleterious effect on stratospheric ozone. The objective of this program is to develop and demonstrate, by 2004, environmentally acceptable and user-safe processes, techniques and fluids that meet the operational requirements currently satisfied by halon 1301 systems in aircraft, ships, land combat vehicles, and critical mission support facilities. The results will be specifically applicable to fielded weapons systems, and will provide dual use fire suppression technologies for preserving both life and operational assets. This effort leverages prior SERDP-funded research and the RDT&E infrastructure that has been created during the ongoing DoD's near-term research program.

TECHNICAL APPROACH AND RISKS: The research approach consists of six parallel Technical Thrusts, closely integrated and structured to achieve specific milestones within an 8-year time frame. This approach was developed collaboratively by government, industry, and academic experts in fire science, the contributing technical disciplines, instrumentation, testing, and current halon 1301-protected weapon systems. The six Technical Thrusts, which embody 24 separate research elements, are:

1. Risk Assessment and Selection Methodology develops a process for choosing among alternative technologies by applying modern decision-making concepts.

2. Fire Suppression Principles establish the mechanisms of flame extinguishment using detailed experimental studies and computational models leading to new approaches for fire control.

3. Technology Testing Methodologies select, adapt, and develop test methods and instrumentation to obtain data on the effectiveness and properties of new suppression approaches.

4. New Suppression Concepts define new ideas for fire suppression based on chemical and physical principles.

5. Emerging Technology Advancement accelerates to maturity a variety of processes, techniques, and fluids that are currently under development.

6. Suppression Optimization develops the knowledge to obtain the highest efficiency of each candidate technology.

This is a "living" program, representing the best current thinking for achievement of the objective, yet adaptable as the knowledge base grows. There are always risks in such an undertaking. For instance, there might be no chemicals that perform well for all the desired properties; no new fire suppression technologies might emerge; optimization principles might not improve mediocre approaches sufficiently; and lab-scale measures might not adequately predict real-scale performance. This research is designed to provide the scientific understanding to maximize the likelihood of overcoming factors.

The FY 1997 projects are:

1.a. Development of Model Fires for Fire Supression Research
2.a. Mechanisms of Ultra-High Efficiency Chemical Suppressants
2.b. Suppression Effectiveness of Aerosols and Particles
2.d. Stabilization of Flames
3.a. Dispersed Liquid Agent Fire Suppression Screen
4.a. New and More Effective Fire Suppression Tecnologies Presently Conceptual
4.a-1. Development of a Self Atomizing Form of Water
4.a-2. Identification and Proof Testing of New Total Flooding Agents
4.a-8. Electrically Charged Water Mists for Extinguishing Fires
4.a-13. Flame Inhibition by Phosphorus-Containing Compounds

BENEFIT: The outcome of this program will be demonstrated alternatives to halon 1301 usage that will enable DoD weapon system managers to make prudent decisions in removing their dependence on a key ozone-depleting substance in a manner that offers the least fiscal and operation barriers to implementation.

FY 1997 Milestones		Planned Date
1.	Program start	10/01/96
2.1	(Proj 1a) Document DoD halon 1301 fire protection systems and threat scenarios	12/31/96
2.2	(Proj 1a) Deduce and document the characteristics of fire scenarios and halon-fire interactions	09/30/97
3.1	(Proj 2a) Complete survey of "superagents" and identify key chemicals for further study	12/31/96
3.2	(Proj 2a) Complete flame structure and extinction studies of $Fe(CO)_5$ and other metallic superagents	11/30/97
4.1	(Proj 2b) Complete apparatus and diagnostic techniques for studying aerosol-flame interactions	06/30/97
4.2	(Proj 2b) Establish range of application for water droplets	08/31/97
5.1	(Proj 2d) Complete construction of flow apparatus for study of flame stabilization by obstructions	02/28/97
5.2	(Proj 2d) Establish worst case obstruction configurations	06/30/97
6.1	(Proj 3a) Complete burner and flow apparatus for measuring the suppression efficiency of gaseous chemicals	03/31/97
6.2	(Proj 3a) Demonstrate capability of the apparatus to measure suppression using liquid aerosols	07/31/97
7.	(Proj 4a-1) Demontrate the effectiveness of CO_2 hydrate on extinguishment of small fires	07/31/97
8.	(Proj 4a-2) Determine the optimal phosphorus nitrides, silanes, siloxanes for further study	08/31/97
9.	(Proj 4a-8) Determine reduced time/mass for extinguishment of small fires by charged water aerosols	05/31/97
10.	(Proj 4a-13) Determine whether and which types of phosphorus-containing chemicals are reasonable candidates for further study	09/30/97
11.	Final Reports for Projects 4a-1, 4a-2, 4a-8, 4a-13	03/31/98

PROJECT SUMMARY

PROJECT TITLE & ID: Life Cycle Costing/Energetics Production; PP-1068

RESEARCH CATEGORY: 6.3 Advanced Development

LEAD AGENCY: U.S. Navy

LAB: Office of Naval Research - Arlington, VA

PRINCIPAL INVESTIGATOR: Dr. James Short

FY 1996 COMPLETED PROJECT

OBJECTIVE: This project has three objectives:

(1) To develop advanced remote sensing techniques to detect and assess change. Those techniques include image classification, clustering, change assessment, spatial statistics, registration, boundary detection and enhancement;

(2) To demonstrate cleaner, higher yield synthetic routes to three 4th generation energetic compounds: 1,3,3-trinitroazetidine (TNAZ), Hexanthrohexaazaisowurtzitane (CL-20), and difluoroamino compounds (DFA); and

(3) To develop an accounting methodology for life-cycle direct environmental costs of a weapon system.

BENEFIT: The proposed software package would accept many different data formats from various sensors. It would provide start-of-the-art change assessment modules and the ability to use any combination in order to analyze a particular image. Cleaner synthetic routes will replace or eliminate the use of undesirable solvents. The new accounting methodology will allocate environmental costs to individual products when multiple products are being simultaneously produced.

ACCOMPLISHMENTS: Work on this project is ongoing through the end of FY 1997. First, it will develop and test a software package to accept many different data formats from various sensors. Second, it will conduct a multi-institution approach that will focus on optimizing existing methods of large-scale synthesis for TNAZ and explore methods to optimize efficiency and cost-effectiveness for CL-20 and DFA. Third, it will further develop and test a prototype Environmental Cost Analysis methodology and identify weapon systems appropriate for the first operational application.

TRANSITION: The results of this project will be integrated with the results of the CAME project (PP-063).

APPENDIX E
Global Environmental Change Project Summaries

PROJECT SUMMARY

PROJECT TITLE & ID: Acoustic Monitoring of Global Ocean Climate; GEC-286

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCY: Advanced Research Projects Agency

LAB: Scripps Institution of Oceanography - La Jolla, CA

PRINCIPAL INVESTIGATOR: Prof. Walter H. Munk

FY 1996 COMPLETED PROJECT

OBJECTIVE: The primary objectives are to make a contribution toward meaningful climate predictions and to assess the potential effects of an acoustic thermometer's low frequency signals on marine life, especially marine mammals. These objectives will be accomplished with an acoustic monitoring system that has been developed to characterize basin-scale ocean temperature variability, using innovative technology to measure changes in acoustic travel time along multi-megameter undersea paths.

BENEFIT: The contributions to improving models of climate change are potentially of great benefit to society. Basin-scale observations of ocean temperature gathered by this program will serve to validate and constrain current climate prediction models. Without such data, the models diverge after a few decades, and result in widely differing predictions of the extent and degree of "greenhouse" warming.

ACCOMPLISHMENTS: The Pioneer Seamount source continues to operate and the California Marine Mammal Research Program (MMRP) has now completed one year of aerial surveys in conjunction with each series of source transmissions. The Barbers Point receiving array became operational, and began receiving signals from the Pioneer Seamount source. Vertical Line Array buoys (pop-ups) have been recovered from both the Hawaii and Christmas Island receiver arrays and initial indications are that the data recovered are excellent. In addition US Navy IUSS receivers are recording the Acoustic Thermometry of Ocean Climate (ATOC) signal and excellent data are being received. Initial results from the MMRP is that there are no adverse effects on marine mammals from the ATOC source operations.

TRANSITION: ATOC operations will continue under the Scripps Institution of Oceanography, Marine Mammal Program, and the Office of Naval Research. SERDP Conservation Project, Marine Mammal Response to Low Frequency Sound (CS-1069), leverages on this research.

PROJECT SUMMARY

PROJECT TITLE & ID: Atmospheric Remote Sensing and Assessment Program (ARSAP); GEC-470

RESEARCH CATEGORY: 6.2 Applied Research

LEAD AGENCIES: U.S. Navy and Department of Energy

LABS: Naval Research Laboratory - Washington, D.C. and Sandia National Laboratory - Livermore, CA

PRINCIPAL INVESTIGATORS: Dr. Phillip R. Schwartz and Dr. John Vitko

FY 1996 COMPLETED PROJECT

OBJECTIVE: This is a joint DoD/DOE program to investigate, understand, and assess global atmospheric change. The research leverages with existing DoD space-based sensors of the middle and upper atmosphere, ongoing theoretical modeling activities, and the development of DOE sensors and measurement techniques for observing the lower atmosphere. This effort focused on the application of unique DoD/DOE ongoing research on environmental issues through measurement of key observables, the validation of climate models, and the assessment of evidence of global atmospheric change. It is coordinated with the US Global Change Research Program (USGCRP) and other national environmental programs.

BENEFIT: These improvements will provide the DoD with enhanced weather data, with redundancy in the case of satellite loss during critical operations, and provide improved infrared backgrounds for weapons systems sensors. The radiation, water vapor, and cloud measurement capabilities will be a major tool in understanding radiation-cloud interactions. Representatives of both the Defense Meteorological Satellite Program (DMSP) and of NOAA have expressed interest in several of the instruments for weather satellite applications. Especially important is the leveraged costs of launching sensors into orbit. Existing data centers will be used for data archiving and management. Data from this activity will be used to provide climate data for long term atmospheric change.

ACCOMPLISHMENTS:

Polar Ozone and Aerosol Measurement (POAM)/Orbiting Ozone and Aersol Monitor (OOAM): The POAM II instrument was launched on 26 September, 1993, and is still operational. Owing to the support of SERDP, the POAM II experiment is returning excellent data and is considered a complete success. The unique data set obtained from POAM has enabled us to document the dissipation of the 1993 ozone hole, and the formation and dissipation of the 1994 ozone hole in unprecedented detail. The FY 1996 work continued improvement of the POAM retrieval algorithms, especially the retrieval of ozone below about 17 km, and water vapor

and nitrogen dioxide throughout the stratosphere.

The effort on the OOAM experiment centered on final fabrication, planning, and instrument calibration tests. Integration onto the Space Test Experiment Program (STEP) 4 spacecraft occurred on January 22, 1997.

Water Vapor Millimeter-Wave Spectrometer (WVMS): The first and second WVMS instruments (WVMS-1 and -2) are now in the field (Lauder, New Zealand, and Table Mountain, CA) and are operational. WVMS-3 is deployed at Table Mountain, CA (TMO) and underwent side-by-side tests with WVMS-2 and was shipped to the Network for Detection of Stratospheric Change (NDSC) facility at Mauna Loa, to begin official NDSC operations. WVMS-4 was deployed to TMO for testing, then at Thule, Greenland for NDSC operations. The measurements provided by these instruments have clearly given the highest quality middle atmospheric water vapor data which has ever been obtained, and they will be a very important part of the NDSC program.

DOE Lower Atmosphere: In the fall of 1995, a DOE-led, multi-laboratory, multi-agency team completed a comparison of clear and cloudy sky measurements using a combination of satellite, vertically 'stacked' aircraft, and ground observations to make highly accurate solar flux measurements at different altitudes throughout the atmospheric column. Early results indicate that cloudy skies do indeed absorb as much as 50 percent more shortwave radiation than previously predicted. Uncertainties in the 'radiation-cloud interaction' account for most of the factor of 3 range in warming predicted by different models. In the fall of 1996, the science team demonstrated the use of a newly developed unmanned air vehicle (UAV) in a record-setting, 26-hour science flight. This is the first ever, airborne radiative flux measurements over a complete diurnal cycle. The science team demonstrated a new UAV long endurance mission capability and provided unprecedented accuracy in atmospheric measurement of the radiative properties of clouds.

TRANSITION: POAM/OOAM operations will be sustained by the Naval Research Laboratory (NRL) and the Office of Naval Research. The NDSC will be operated by NRL with NASA sustaining support. Part of the DoD program will undergo transition to the DMSP in the form of upper atmospheric weather monitor. The improved low altitude measurement capabilities are an important component to DOE's Atmospheric Radiation Measurement (ARM) program. All DOE data will be available through the Global Climate Data Information System (GCDIS) center at Oak Ridge.

APPENDIX F
FY 1998 Statements Of Need

Cleanup

Compliance

Conservation

Pollution Prevention

Novel Systems for the Detection and Identification of Buried Unexploded Ordnance

OBJECTIVE: The primary focus of this need is to develop, refine, and integrate novel sensing technologies with high-performance sensor fusion and signal processing algorithms for enhanced detection, location, and discrimination of buried UXOs under a wide range of environmental conditions. It is oriented toward UXO clearance in noncombat situations.

BACKGROUND: Current estimates indicate that up to 11 million acres of land in the U.S. contain UXO as a result of military training and weapons testing activities. The present cost of identifying UXO, driven largely by the need to exercise extreme safety precautions, ranges from $400 per acre for surface UXO to $1.4 million per acre for sub-surface ordnance. Advanced techniques for modeling the propagation of electromagnetic, magnetic, seismic/acoustic, X-ray, nuclear, or optical energy through soils under varying environmental conditions, and predicting its interaction with a wide range of UXO targets are needed. Support through SERDP will fully develop these capabilities using greatly expanded, modern modeling and simulation tools and techniques to provide a cost-effective detection, discrimination, and remediation capability. Multisensor approaches, together with high-performance sensor fusion and signal processing technologies will be integrated into prototypes for detection of buried UXO.

The effects of the sub-surface environment on buried UXO sensor response will be investigated together with development or modification of data fusion and UXO discrimination algorithms. Research and development activities will be conducted at the bench and laboratory scale to identify physical, chemical, and biological factors affecting buried UXO technologies. Research will stress the first principles of technology application. Pending successful bench scale research, activities will be transitioned to field testing and demonstration at prepared and actual UXO sites to verify laboratory findings. Field-tested prototypes will be transferred to ESTCP or another 6.4 Program Element, as feasibility is demonstrated, or directly to DoD users.

This research will deliver enhanced understanding of the interaction of buried UXO sensor response and environmental conditions, and a prototype multisensor system for enhanced buried UXO detection. Successful development of UXO detection technology will aid in the development and commercialization of sensor systems to address the UXO problem. Because of the magnitude of the problem, relatively small increases in performance efficiency can result in substantial cost savings.

Dense, Non-aqueous-phase Liquid (DNAPL) Source Zone Identification

OBJECTIVE: This statement of need seeks innovative technologies to detect, locate, quantify, and determine the horizontal and vertical extent of DNAPLs (ganglia and free-product phases) in the subsurface environment. Emphasis is on nonintrusive or minimally intrusive technologies for identification of DNAPL source zones. It focuses on innovative solutions and approaches that would ideally provide the desired information in real-time and in an easily interpretable format rather than enhancements or modifications of existing technologies. Efforts will complement or interact with other research in this area of sensor development.

BACKGROUND: Scientists and engineers are increasingly recognizing that DNAPL contamination is a very serious, widespread problem, without a ready, economical solution. One study found that up to 85 percent of Superfund sites have contaminated groundwater, and about 75 percent of those are contaminated with DNAPLs. Currently there are no acceptable, cost-effective methods for accurately locating, removing or treating DNAPLs. Successful remediation requires that source areas be located and cleanup initiated at the concentrated source to be economically feasible. Techniques for locating DNAPL sources and accurately estimating their mass are critical to cost-effective cleanup. Being immiscible with and denser than water, DNAPLs migrate downward when spilled on the ground and can accumulate below the water table. One widely used, but for the most part inaccurate, concept is the "pool of DNAPL" sitting on top an aquitard. This simple description implies that the DNAPL could be easily located and extracted, but this is rarely the case. A more realistic concept is "DNAPL ganglia," micro-scale globules dispersed throughout the soil matrix's interstitial space. The DNAPL may remain in the vadose zone or migrate below the water table. It may adsorb on, or absorb in, soil materials and may volatilize to soil gas. Any of these sources may contaminate the groundwater. Consequently, DNAPLs are difficult to locate and remove, and transport is complex, involving many interacting forces. Once in the subsurface, DNAPLs are long-term sources of groundwater contamination and may persist for centuries.

The anticipated products from these efforts are technologies that can detect and delineate subsurface DNAPLs at contaminated sites, which will lead to more cost-effective characterization and remediation of DNAPL contaminated sites. Besides the USAF, the Army and Naval Facilities Engineering Command will use the developed technologies at other military installations. There are also potential users in private industry involved in the manufacturing and use of degreasing compounds and DNAPL-related chemicals.

In-Situ Treatment/Stabilization Technologies: Cleanup of Contaminated Groundwater, Soils, and Sediments

OBJECTIVE: This wide-scope area of need addresses issues of remediation of soils, sediments, and groundwater containing multiple, possibly interacting contaminants, and the investigation of the feasibility of cost-effective treatment trains for these materials. The primary requirement is to develop innovative, in-situ treatment/containment/stabilization technologies combined with volume minimization, which will potentially have a high payoff.

BACKGROUND: Cleanup of sediment, soil and groundwater contaminated with heavy metals, organics, and hydrocarbons is often difficult and can be prohibitively expensive or unfeasible. Remediation efforts that employ in-situ removal/stabilization technologies usually increase exponentially in cost when the contaminated subsurface is heterogenous, when contamination is low concentration but extensive, or when access to the subsurface is difficult due to restricting surface structures or uses.

A need exists to investigate technical monitoring and management of components of integrated treatment processes such as in-situ bioremediation, size separation to minimize volume requiring treatment, metals leaching, and improved underwater capping, to establish a baseline. Those methods with the greatest promise will be demonstrated on a laboratory scale before being field-tested and transferred to ESTCP or another Service 6.4 Program Element as feasibility is demonstrated. Substantial research and development resources within DoD are currently devoted to the development and demonstration of innovative technologies. SERDP, ESTCP and AATDF fund ongoing projects attempting to develop and define technologies to replace pump-and-treat alternatives. The Navy and Army have partially funded and extensively interacted with the National Research Council (NRC) through its Marine Board Committee on Contaminated Sediment Remediation. The group is providing a joint report on contaminated sediment technology assessment.

Risk-Based Cleanup Assessment Techniques

OBJECTIVE: The primary emphasis of this need is to develop scientifically defensible response analysis techniques as drivers for risk assessment methodologies used to screen hazardous waste sites. Extrapolating these techniques to ecologically relevant parameters and quantifying uncertainty will facilitate technically defensible and cost-effective environmental risk assessments (i.e., "how clean is clean").

BACKGROUND: Current approaches for characterizing the ecological risk posed by contaminated media rely heavily on simple bioassays to integrate the toxic effects of the numerous contaminants present in a mixture. While such measures of toxicity effectively account for differences in contaminant bioavailability and toxicity, they often lack true ecological relevance. Modeling methodologies are required that will extrapolate observed effects on bioassay organisms to endpoints of greater ecological relevance, e.g. population dynamics, higher trophic levels, community structure, and, ultimately, ecosystem quality. The application of such modeling techniques will ensure that cleanup goals are based on ecological relevance rather than analytical capability (i.e. detection limits).

Screening methods, which are limited in part due to the paucity of whole organism dose-response information, will be developed for military unique compounds. These methods will permit rapid and cost-efficient screening evaluations of the potential for media to produce toxic effects in ecological and human receptors, and will also address complex mixtures of contaminants, which predominate at DoD installations and may interact to affect toxicity. Techniques must also be developed for quantifying the uncertainty associated with estimates of environmental risk. Uncertainty analysis performed during risk assessments conducted to date generally include only qualitative, narrative descriptions of the uncertainties associated with the risks described in the assessment. Such qualitative uncertainty analysis in many cases is insufficient given the high costs of cleanup. Quantitative techniques such as stochastic modeling methods and fuzzy logic are required for integrating exposure and effects information and describing uncertainty.

Destruction Of Energetics In Production and Demilitarization

OBJECTIVE: The SERDP desires to assist in developing an innovative technology or a system of technologies that can efficiently and cost-effectively treat energetic materials and render them non-hazardous by a means that is environmentally friendly and does not employ OB/OD.

BACKGROUND: In its role as the Single Item Manager for DoD conventional munitions, the Army must be able to dispose of all DoD propellants/explosives/pyrotechnics production wastes. These energetic materials, by their very nature and design, are reactive. When these energetic materials do not meet specifications during manufacture, or have reached the end of their useful life through instability or obsolescence, they must be rendered non-reactive and, if possible, non-hazardous prior to disposal. Restriction of OB/OD poses different problems for the disposal of production wastes from those encountered in the demilitarization of obsolete or unstable munitions. By their very nature, off-specification production waste energetics are unpredictable, and cannot be manifested and transported off-site. To handle such wastes, on-site treatment and disposal technologies are required. Alternatives to OB/OD for production wastes must take into account the potential irregular shape size and bulk of such wastes. Demilitarization of munitions, on the other hand, requires safe disassembly, removal of the energetic materials from the shell and projectile and subsequent treatment of the energetic material prior to disposal.

The investigated destruction process, preferably, will apply to both production and demilitarization waste energetics, and must take into account such factors as reaction kinetics and energy release rates, environmental releases to all media, and operating concerns such as corrosion and scale formation. Ideally it will be able to handle multiple classes of energetics (i.e. nitroaromatics and nitramines, single/double/triple base propellants and those containing ammonium perchlorate). Thermal destruction, oxidative and reductive chemical reactions, and beneficial reuse potential of final product will be considered.

Development of such technologies will provide an alternative to OB/OD practices and allow compliance with regulations promulgated as a result of the Clean Air Act Amendments of 1990.

NOx Control Technology For DoD-Specific Combustion Devices

OBJECTIVE: SERDP seeks to identify and develop innovative technologies for reducing N-based emissions from the following sources to meet federal and local air quality standards of the Clean Air Act Amendments of 1990 (CAAA-90): (1) liquid-propellant rocket fueling or defueling operations; (2) aircraft turbine engine exhausts; and (3) diesel- or turbine-powered mobile heavy equipment subject to limitations to increased size or weight.

BACKGROUND: Exhausts from liquid-propellant rocket fueling and defueling operations contain separate streams of hydrazines and of N_2O_4 in oxygen-free nitrogen. Decontamination is accomplished by wet scrubbing, and conversion to dry scrubbing is being considered. Both approaches are adequate, but both generate large volumes of hazardous condensed-phase wastes requiring additional treatment processing. The current alternative being explored is dry scrubbing, which offers improved removal efficiency but would continue to generate solid wastes requiring disposal.

Current military aircraft turbine engines produce an exhaust that contains significant quantities of pollutants that are spectroscopically identifiable (providing an information-rich trail) and suspected of causing significant disturbance to the chemistry of the middle atmosphere. Fuel additives have been no more than minimally effective, and no post-combustion control methods have been demonstrated.

Diesel-powered mobility hardware is presently under extreme regulatory pressure asking for drastic reduction in the amount of combustion-derived byproducts emitted. Any modification to the operating unit that increases its weight or size would decrease its transportability. One cumbersome, bolt-on technology has been demonstrated, and the ultimate fix is expected to come from industry; however, a more-compact bolt-on technology or a drop-in dual-function device replacing an existing component is needed for the interim.

Operational mission capability will be preserved by: (1) meeting increasingly stringent regulatory standards; (2) decreasing the generation and disposal cost of hazardous wastes from existing wet-scrubbing controls; and (3) decreasing the spectroscopic signature of tactical flight operations. All DoD Services would benefit from technology to reduce NOx emissions from a variety of vehicles.

Particulate Emissions Characterization

OBJECTIVE: SERDP seeks to develop innovative technology for sampling and characterization of fine particulate matter (PM) in exhaust from jet engines, painting/depainting facilities, aircraft ground equipment operation, and boiler operation. The sampling and characterization technologies will include size (ranging from less than 1 to 10 micrometers) and chemical composition in order to meet the National Ambient Air Quality Standards (NAAQSs) at DoD facilities.

BACKGROUND: The NAAQS established by the Clean Air Act (CAA) regulate PM as a criteria pollutant. The PM NAAQS, currently specified as PM-10, regulates emissions of particulate matter with diameters less than 10 micrometers. Because of the known health risks associated with particulate matter, this standard is currently under review by EPA and will probably result in additional and more stringent standards in the very near future. The new standard will likely place greater restriction on particulates with diameters less than 2.5 micrometers, creating a large number of PM-non-attainment areas and establishing a requirement to control or reduce particulate emissions of this nature.

Particulate matter can also degrade performance or destroy electronic equipment, and significantly interfere with signal transmission through the atmosphere. Airborne particulates also constitute an observable signature that can be used to locate and identify the emitting source.

A number of DoD operations produce significant amounts of PM emissions which are largely uncharacterized. While there are several methods to determine the size of PM, there is no one method which covers the entire size range of interest. And, although current techniques do not allow the combination of chemical and size analysis, near-term advances in measurement techniques may provide this crucial information. For instance, it would be of great value to know the exact size range that contains toxic compounds for the design of pollution control devices. Field measurement of PM is also needed to improve the state of PM models. Other work is needed to investigate reactions which produce secondary organic PM having unknown toxicological mechanisms.

VOC Control Technology For Aircraft Painting and Depainting Facilities

OBJECTIVE: SERDP seeks to develop innovative technologies and approaches that provide cost-effective control of both particulate and VOC emissions generated by spray application of surface-preparation and -coating activities for aircraft.

BACKGROUND: Promulgation of the National Emissions Standard for Hazardous Air Pollutants (NESHAPs) [implementing the Clean Air Act Amendments (CAAA) of 1990] specific to the application and removal of coatings from aerospace vehicle surfaces is forcing military organizations to make major decisions between (a) investing in control methods to bring existing painting and depainting operations into compliance with stringent emission limits or (b) replacing the existing, proved technologies with untested painting and depainting methods.

Efforts to develop replacement coatings have not yet delivered universally acceptable products. Thermal, abrasive, and solvent concepts, separately and in combination, are actively being tested as depainting methods, but both accumulation of long-term evaluation data and qualification of processes for individual aircraft systems will be completed long after the compliance deadlines. Practical VOC control technologies are available but generally uneconomical at the airflows required to ventilate a hangar.

Numerous feasible options are presently available, but they have not been fully demonstrated and/or validated in DoD applications. A nonthermal discharge control system is scheduled for testing at NAS North Island, and alternative approaches to regenerating carbon adsorbents are being evaluated. A biofilter control system is scheduled for demonstration and validation at Hill AFB.

The primary users of this technology include all DoD depots and facilities that involve painting or depainting in the repair or maintenance of aircraft. It is expected that the overall life-cycle cost of equipment maintenance will be minimized by decreasing the cost of bringing noncompliant painting processes into compliance with the regulatory standard, and thus decrease the pressure to force the adoption of insufficiently tested process modifications.

Minimization of Oily and Non-Oily Waste

OBJECTIVE: SERDP seeks to develop a treatment process specifically directed at reducing oil concentration in ship discharges. It is part of a two-pronged effort being launched to address the problem of oily and non-oily waste. The other is a wastewater minimization approach within the Pollution Prevention Thrust Area. Technologies which produce a reduced, but hazardous, wastewater are not within the scope of this SON.

BACKGROUND: International, Federal, State, and local environmental regulations limit the discharge of oily and non-oily wastewater from ships and land-based activities into receiving water bodies and sanitary sewers. Wastewater aboard ships is generated by domestic, hotel, and commissary functions, as well as, industrial and machinery maintenance activities. The wastes contain high levels of suspended solids, biochemical oxygen demand, fecal coliform bacteria, oil and grease, and heavy metals, all of which must be treated or off-loaded daily. Tightening Federal and State water quality standards and stricter regulation of foreign ports and harbors continue to increase the cost of waste off-load, on-site treatment, and compliance with foreign and domestic environmental laws. The Navy anticipates a total cost in excess of $1,490M to off-load wastewater from ships over the next 20 years unless minimization and treatment techniques are implemented aboard ships. The development and implementation of equipment for wastewater minimization and treatment aboard government and commercial vessels offers the promise of significant cost reductions as a result of reduced waste off-load and treatment requirements. Technologies and processes that are developed to meet the rigorous design standards required by naval ship combatants can be readily applied to less restrictive commercial ships and over-land transportable requirements of the Army and Air Force.

Assessment and Prediction of Military Noise Effects on the Environment

OBJECTIVE: The objective of this statement of need is to improve our understanding of the impacts of military noise on the environment, and to provide tools and methodologies for noise impact assessment that would be usable by all military Services. Methodologies and approaches should pursue a risk assessment/risk management approach.

This project will provide the DoD with new and innovative tools and methodologies to determine noise impacts on the environment and to predict how modifications in military training and testing would help mitigate impacts.

BACKGROUND: Military training and operations often cause tremendous increases in background noise levels in the environment. Military-related noise is caused by ground vehicles, aircraft, and weapons. These noises are loud and many times sudden, causing potential startle effects. Some noises may be so extreme that exposures could cause health problems. Technology gaps exist for understanding aspects of noise propagation, noise modeling, and noise effects on humans, animals, and structures.

Noise research for military training and operations is extremely important and is reflected in the high priority ratings for research on the effects on threatened and endangered species (US Army need) and effects from aircraft and space launch vehicles (US Air Force need). The US Navy has high priority requirements to assess the impacts of their operations on marine mammals and other elements of the environment.

Noise resulting from military training and operations potentially impacts ecosystems, humans, and wildlife in various types of habitats, threatened and endangered species, historic buildings and monuments. It is the responsibility of the military organization to describe proposed changes in operations and the impacts of those changes according to the National Environmental Policy Act. Environmental managers must be provided the tools with which to accurately describe the military operations proposed, the potential increase in noise exposures to the environmental resources in question, and how the additional noise created may impact the environment. Environmental managers also must be given the tools to predict the potential impacts of military operations and attempt to make changes to the proposed operations or mitigate the impacts.

Military Training & Testing Activity Impacts On The Environment

OBJECTIVE: The main objective of this statement of need is the development of effective standard and robust methods as well as validated data defining, under varying conditions, military activity impacts on the environment. Specifically, the overall goal is to develop, test, and disseminate a set of standard methods and validated data defining military activity impacts for inclusion into existing and planned modeling, decision making and management tools.

The results of this project will provide a standard set of information about selected military training and testing activity impacts to feed into a range of assessment and management tools.

BACKGROUND: Military activities result in impacts to natural systems. Some are obvious while others are insidious and pervasive, and still others are not readily apparent. Some are actually beneficial, depending on circumstances and desired outcomes. A good example of beneficial impact is the role military activities generating range fires have played in furthering fire based ecosystems. Many military impacts are not readily apparent. Impacts occur in all DoD operating environments, the oceans and coastal waterways, in the atmosphere, and on land or underground. The process of impact may be so slow that the relationship between cause and effect can go undetected. It is important to know and understand the effects, relationships, and dynamics of these actions in order to quantify risk and respond responsibly. Too little is currently known about the full environmental impacts resulting from a broad range of military training and testing activities. Opportunities may exist to identify high priority impact categories for which insufficient data, assessment methodologies, and/or understanding exists and to define a research study to address these insufficiencies in a strategic manner.

Mitigation/Rehabilitation of Damage Caused by Military Training and Testing Impacts

OBJECTIVE: The main thrust of this statement of need is to focus on improved technologies for mitigation and/or rehabilitation of damages resulting from military training and testing impacts. The specific objective is the development of techniques to improve the DoD's ability to mitigate and/or rehabilitate damage or other adverse impacts, or the potential thereof, associated with military training and testing on land, water, or air. The research proposed should address one or more of the high priority needs for mitigation and/or rehabilitation applied to natural or cultural resources, as further specified below:

(1) More traffic-resilient plant cultivars are needed to improve the wear-resistance of land-based maneuver training areas.

(2) An improvement is needed in basic knowledge of freeze/thaw processes in soils, and how these processes affect soil compaction, erosion, and potentially, rehabilitation/ mitigation.

(3) Mitigation measures are needed to protect sea turtles and their beach habitats from the impacts of military training/testing.

(4) Methods for rehabilitation/mitigation of damage from military activities on desert surfaces and other barren and fragile surfaces.

BACKGROUND: Military training and testing often causes damage to land, vegetation, habitat (terrestrial and aquatic/marine) and other environmental components. Because these activities continually recur, mitigation and rehabilitation measures must regularly be employed to ensure ongoing sustainability of military training and testing resources, as well as to support DoD environmental stewardship responsibilities. In some cases, similarities between military and non-military impacts allow the adoption of mitigation/rehabilitation techniques developed for civilian use. In many cases, the military impact is sufficiently unique that special measures must be developed or adapted for mitigation and rehabilitation.

Landscape Level Change Detection to Support Carrying Capacity Analyses for Military Ranges

OBJECTIVE: The main objective of this statement of need is to improve the capability of DoD land managers to accurately detect broad-scale changes occurring in the environment of land-based training and testing areas and their vicinities, including shallow coastal zones. This includes improving the capability to accurately and reliably extrapolate field data for broad-scale, full spatial coverage by the use of remote sensing techniques.

The capabilities produced by this research will significantly improve the accuracy and cost/time-effectiveness of data collection, monitoring, and modeling for military land management purposes, not only for carrying capacity per se, but for most other land management requirements. Any land management effort is likely to require or benefit from techniques for cost-effective environmental change detection and extrapolation of field data through the use of remotely sensed data.

BACKGROUND:

The Department of Defense has a need to better characterize and quantify the ability of DoD land resources to support military training and testing in a sustainable manner.

Validated temporal and spatial techniques/methodologies are needed to monitor change in vegetation cover, amount and condition for various ecoregions, using a combination of remote imagery and field surveys. Such models for temporal analysis and change detection need to be refined for different ecoregions, and the necessary image calibration techniques developed. The model output must provide spatial analysis of relative change in vegetation parameters, based upon remotely sensed images at appropriate temporal intervals, which can be used to assess and recalibrate carrying capacity models and assess changing habitat conditions for threatened, endangered, and other species of interest. The change detection methodologies need to be sensitive enough to detect changes above or below critical threshold levels for different ecoregions.

Ecosystem Fragmentation, Including Threatened and Endangered Species

OBJECTIVE: The primary objective of the statement of need is to improve basic scientific understanding of the effects of fragmentation on ecosystems and on T&E habitats in the context of military training/testing areas and their surrounding regions. Specific studies are needed to improve scientific understanding of ecosystem/habitat fragmentation effects and processes on military training/testing areas, especially with respect to the following questions: Does fragmentation within military training/testing areas create adverse impacts on the sustainability and survivability of T&E species in those areas and/or in the larger surrounding regions? Are the criteria used for setting T&E habitat areas off-limits to training/testing currently too strict, or not strict enough? Is fragmentation on training/testing areas causing adverse impacts on the sustainability of natural ecosystems in these areas?

BACKGROUND: Habitat fragmentation has been identified as the most significant threat to biodiversity world-wide (cf. for example Noss & Cooperider, Saving Nature's Legacy: Protecting and Restoring Biodiversity, 1994). The two components of fragmentation are: 1) reducing overall habitat area, and 2) division of the remaining habitat into smaller and more isolated parcels which may not be enough to sustain the organisms and the ecosystem upon which they are dependent. As fragmentation increases, habitat patches decrease in size and become more isolated, until eventually the gaps occupy more space than the habitat does. Fragmentation not only reduces habitat size and quality, but may often change species composition and the structure and functioning of the remaining patches of the ecosystem. Fragmentation-tolerant species are favored by the new conditions, while many original species of the ecosystem may die out under these conditions. Fragmentation has deleterious effects on biodiversity at the landscape level, species richness level, and genetic diversity level. There are three facets to the problem of spatial fragmentation on DoD training and testing areas. One is fragmentation of habitats by permanent altered areas on the training/testing area itself. Secondly, fragmentation of the habitats and ecosystems outside the perimeters of the training/testing area may reduce habitat quality enough to cause species to take refuge inside the training/testing area. Thirdly, the necessity to place training/testing space off-limits because of the presence of threatened or endangered species causes a fragmentation of the "habitat" for training/testing use.

Error and Uncertainty Analysis for Ecological Modeling and Simulation

OBJECTIVE: This statement of need seeks methods and capabilities to quantify the sources of error associated with land management models, as well as their underlying assumptions and data sources, and to evaluate the consequences of changes to the models and to the input data on the reliability of predictions (outputs) produced by the models. The objectives of this work are (1) to provide an integrative and interactive computerized context for ecological and related kinds of modeling for environmental management on military installations and ranges; and (2) to ensure that all the components are compatible with one another, with the data sources, and with the overall system, and provide standards by which new components can be developed in a compatible manner. Specifically, the main focus should also include capabilities to develop methods to fully evaluate the effects of individual errors and groups or sequences of errors (both model errors and input data errors) on multi-component model predictions, and to identify weaknesses in the models, multi-model interfaces, and input data; and to reduce such errors and uncertainty where possible.

BACKGROUND: As the Services begin to use the land management models currently under development in their land management decision processes, there will be a need to tie the modeling efforts back to the ongoing data gathering/monitoring programs. The land management decision support systems used by the Services should be developed in such a way as to provide the means and rationale to validate the assumptions made, confirm or discount specific types and sources of data or methods of capture, and prioritize data acquisition, as well as to institute quality control/quality assurance programs. To date, there are no means or rationale by which to assess the sufficiency and accuracy of the military's data and data collection programs for natural/cultural resources. It is hoped that this project will: (1) provide an integrative and interactive computerized context for ecological and related kinds of modeling for environmental management on military installations and ranges; and (2) to ensure that all the components are compatible with one another, with the data sources, and with the overall system, and provide standards by which new components can be developed in a compatible manner.

Fundamental Ecosystem Processes, Including those Relating to Threatened and Endangered Species

OBJECTIVE: The main objective of this statement of need is to: (1) gain the basic knowledge necessary to support decision making for sustained use, management, mitigation, and restoration of ecosystems used or impacted by military training and testing; and (2) develop methods to characterize a natural setting and its dynamic ecological processes in order to accurately test a product's performance in the context of the environment. Fundamental ecosystem processes knowledge is needed in particular to support regional-scale or large-scale management, enhancement and recovery of threatened/endangered plant and animal populations within the context of their natural plant communities. The species of importance to DoD are those whose habitats are to a significant degree contained within or near military installations or training ranges.

BACKGROUND: There are certain ecological processes of vital and immediate relevance for DoD use and management of land, marine, coastal, air, and other ecological space. Among these relevant processes are those having to do with the responses or reactions of environmental variables to military activity impacts, and to DoD management and mitigation efforts: processes such as natural and artificially enhanced recovery, adaptation, and natural mitigation. Among the kinds of questions to be asked are: "How does the ecosystem/species/habitat respond to military impacts over the short and long term, and what can we do to enhance the positive effects of these natural processes? Is it effective and necessary to try to enhance the natural processes, or not?" DoD needs access to an expanded knowledge base of fundamental ecological processes--knowledge that can be packaged into ecological models, but that is targeted very specifically toward DoD management and mitigation requirements that support the training/testing mission. Particular emphasis is on ecosystems and ecosystem processes which support biodiversity and which protect or assist in recovery of threatened/endangered species, where military installations or training ranges represent significant portions of these species' habitats and populations.

Non-Polluting Composites Remanufacturing and Repair for Military Applications

OBJECTIVE: Innovative technical solutions to solve pollution problems in composites remanufacturing and repair for military applications are the objective of this program. Specific areas to be addressed include: resins and repair adhesives of finite shelf life; solvents and strippers; and better materials and repair methods.

The cost and bulk of hazardous waste disposal will be greatly diminished for each repair and remanufacturing facility. Each of these facilities could realize savings on the order of several million dollars with respect to disposal costs. In addition, the costs associated with capture and disposal of VOC and HAP materials will be reduced as will the potential worker exposure to these materials.

BACKGROUND: Polymeric composite materials are used extensively throughout the military and energy industrial base complex. Their light weight, high strength and low corrosion properties make them the materials of choice for aircraft, electronics, structures, personnel protective armors (helmets, small arms protective vests), and components on weapon, vessel and vehicle systems. In 1991, the Air Force commissioned Universal Technology Corporation to assess the use of composites throughout the military. The reported use of composites by the Army, Navy and Air Force led to the conclusion that composites are a critical technology in meeting many weapon systems performance requirements. The large number of Air Force and Navy aircraft make extensive use of composites to take advantage of the high weight savings and performance payoff. This is also true of Army helicopters. The new Comanche extensively applied composites including primary structural members, composite armor for the crew compartment and composites in the engine compartment. The use of composites will continue to increase, with the expected production of all-composite systems like the Army's Composite Armored Vehicle (CAV). Full scale production of a vehicle, like CAV, will involve manufacturing 3.6 million pounds of composites per year.

Green Packaging - Reducing Hazmat Consumption and Hazardous and Non-Hazardous Waste Streams From Military Packaging Operations

OBJECTIVE: Innovative technical solutions to urgent environmental problems attributed to Packaging Operations and/or Packaging Materials will be the focus of this program. The two specific areas of packaging that are the focus of this statement of need are: Alternate Materials for Twenty Year Storage Requirement for Ammunition, Weapons Systems, and Ancillary Equipment (*Priority Area One*); Alternate Materials for Five Year Storage Requirement for Subsistence Items (*Priority Area Two*). Solutions will focus on the elimination or reduction of the use of hazardous materials used in the manufacture of packaging materials, examine biodegradable alternatives for packaging materials, develop alternative uses for military unique packaging materials (recycling), and develop technologies to identify and sort packaging wastes to reduce solid wastes. Programs will be targeted at a variety of military unique environments and will focus on military unique materials and processes. Emphasis is strongly urged on programs that focus on eliminating hazardous and non-hazardous packaging materials required to meet the requirements of MIL-STD-648, MIL-STD-1904, MIL-STD-1660, and/or MIL-STD-2073-1. The reduction at the source of packaging material will greatly reduce the great quantities of waste materials that must be disposed of during military operations. The reduction in the logistics burden of trash removal is just one part of the problem. In many cases this trash must be returned to ports or depots for proper disposal, requiring the expenditure of financial resources as well as time. This will be reduced or eliminated under successful development of the packing materials developed as part of this program.

BACKGROUND: The United States Military must support its troops throughout the world with a vast range of sustenance, medical and war-fighting supplies. These supplies are critical and must arrive fully usable anywhere in the world often under adverse handling and environmental conditions such as extreme temperatures not encountered in the commercial logistics arena. Furthermore, many items are produced and stored against wartime surge requirements with a shelf life of over 20 years. To meet these unique and demanding requirements, the DoD utilizes enormous quantities of packaging materials and has developed rigorous packaging procedures and military unique specifications. Extensive testing and actual field use give the assurance that supplies packaged to these methods will remain safe and reliable under these conditions.

Manufacturing/Industrial Recycling In-Process Recycle/Recovery (Recycle and Reuse of Industrial Cleaning Rags)

OBJECTIVE: The objective of this statement of need is to identify and develop an innovative process or processes to remove toxic pollutants from industrial surface cleaning rags which otherwise must be disposed of as hazardous waste. The ideal technique to meet this need will have the following criteria. First, the technique must render the rags free of contamination and make them available for recycling and reuse. Second, the technique must collect the contaminant for safe disposal, or recycle it for proper reuse, or render the contaminant non-hazardous. Finally, the technique must not transfer the toxic contaminants to a second media resulting in later discharge to the environment. The cost savings in reduced hazardous waste disposal will be very evident. At present, many depots must dispose of these rags as hazardous waste costing over a $1/lb with quantities exceeding several hundred thousand pounds per depot per year. It will also reduce the quantity of material that must be disposed of thereby reducing the need for additional disposal sites.

BACKGROUND: Industrial cleaning rags used in DoD and DOE manufacturing and maintenance facilities are typically considered hazardous, and are disposed of as hazardous waste. Their use can be found both onshore in production and maintenance facilities, and in naval and merchant ships at sea. The waste contaminants contained on the rags after use include pollutants such as chemical solutions and reagents, toxic solvents, filtration media, oils, and greases. Once contaminated the rags are collected as hazardous waste for disposal in certified landfills at many times the volume of the original contamination. At present, there is no acceptable method to handle wipe rags without generating a secondary waste stream. Laundry methods have been used for oil and grease containing rags, however, this process only transfers any toxic contaminants to a second media which results in the eventual discharge to the environment.

Warner Robins ALC, GA, a typical aerospace depot facility, for example, is reported to generate more than 115,000 lbs of hazardous waste rags at an annual disposal cost of approximately $150,000 per year.

Non-Toxic Aerospace Sealants and Primers

OBJECTIVE: The identification, optimization, field testing and demonstration of non-toxic sealants, sealers and structural adhesives and primers will be pursued under this program in order to reduce aerospace facilities toxic release inventory and decrease human exposure to toxic substances, primarily those that contain chromate (VI). Other related materials and processes exist and should also be addressed to eliminate, to the maximum extent practical, chromates from aerospace related operations. The payoff to the user community is compliance with existing and proposed human health and environmental regulations, minimization of employee and community exposure to chromates, reduction in hazardous waste (HW), reduction in toxic release inventory (TRI), and implementation of technology that increases affordability by elimininating medical surveillance programs and special monitoring facilities.

BACKGROUND: Several types of chromated sealants and related materials and processes are required in aerospace (aircraft systems and subsystems including airborne weapons and related support equipment) manufacturing, maintenance, repair and long term preservation operations. Most sealants are polymeric and are applied as an environmental barrier that may also have electrical conductivity and corrosion resistance properties. These materials provide their corrosion prevention through leaching chromates that are identified as toxic and targeted for reduction. Sealant materials are used in aerospace structures and skins and are periodically removed and replaced due to degradation. The removal and re-application of these materials generates hazardous waste and exposes personnel to hazardous substances. In addition to polymeric sealants, no substitute currently exists to perform a chromated seal to existing non-chromate aluminum alloy anodizing and magnesium alloy passivation processes. Finally, some aerospace structural adhesives also require chromium for optimum performance.

Alternatives to Aqueous Electrodeposition of Chrome in Gun Barrels

OBJECTIVE: An innovative alternative dry (non-aqueous) process for the deposition of chrome or other materials equally suited for the bore protection of a gun barrel to replace the aqueous electrodeposition process is being sought. The presently used hexavalent chrome, a known carcinogen which exists in the process as both aqueous liquid and gaseous form, must be replaced as well as other stations of the plating process which also produce less dangerous yet still hazardous waste, sulphuric acid and phosphates. Research shall be directed in the area of different dry processes for the deposition of chrome on medium caliber weapons. Since the chrome deposited with the current method has had reasonable success, chrome deposited with the new dry process must be characterized and results compared with existing chrome deposits. The same or greater success should be expected and demonstrated. The new process needs to be analyzed and modeled. The dry process should be evaluated for robustness, i.e., consistency of results, uniformity of deposit, repeatibility of deposit, and extrapolation of the process to large caliber weapons. A significant reduction or elimination of waste solution treatment and sludge removal and the associated costs of the operation are expected payoffs of the proposed work. An increase in worker safety because of the clean process as well as the cleaner and easier production process for medium caliber gun barrels are also anticipated. Unlike aqueous electrodeposition, dry processes are not limited to a single refractory metal. Therefore, coating materials in addition to chrome will be available for deposition and an improved deposited material may be realized.

BACKGROUND: Current weapon systems, and those being developed or in the planning stage today, will have gun tubes with chrome as a protective deposit on their interior/bore surface. This protective cover protects the bore surface against the harsh environment of the hot propellant gases, the thermochemical effects, and the mechanical effects of the projectile, increasing the life of the gun tube. Chrome is deposited onto the tube surface using aqueous electrodeposition. The chromic acid used in the deposition process is a hazardous substance as it is primarily hexavalent chrome. Chromium, although an adequate refractory metal for the erosion and corrosion protection of gun tubes is a major problem when it comes to environmental pollution prevention efforts and worker safety. Hexavalent chromium, in the aqueous liquid and gaseous form, is a known carcinogen which is extremely expensive to dispose of because of its toxic nature.

Substitutes for Ethylene Glycol for Aircraft Deicing

OBJECTIVE: Innovative candidates for an environmentally benign drop-in substitute(s) for glycol-based aircraft de-icing/anti-icing chemicals will be the focus of this program. Successful candidates must meet minimum performance requirements in the following key areas: environmental; toxicology; de-icing/anti-icing performance; and materials compatibility (MIL-A-8243D). Optimum candidates will be subjected to all tests necessary to qualify for use on aircraft under current industrial specifications and submitted for subsequent field tests.

Captured de-icing materials add to the numerous problems already being addressed by runoff and waste treatment experts. The development of an environmentally friendly aircraft de-icing material will allow its use without the need for capture or treatment before release into the environment without causing harm.

BACKGROUND: In fiscal year 1993 the Air Force used more than 130,500 gallons of ethylene glycol and/or propylene glycol based aircraft deicing/anti-icing fluids (ADAF). During the same season, one naval facility recorded using about 11,920 gallons of ADAF. A substantial percentage (49 to 80 percent) of this glycol and water solution falls off the aircraft and enters the parking apron's storm water drainage system. Many of these storm water drainage systems eventually discharge into watersheds adjacent to the airfield. The primary concerns associated with deicing fluids are toxicity and biological oxygen demand (BOD). Propylene glycol (PG) has been thought to be a worthy substitute for ethylene glycol (EG) as an aircraft deicing fluid as it is far less toxic. However, PG exerts a greater BOD than EG. Because of the unique military materials compatibility issues, a commercial solution may not completely address the DoD requirements.

The current chemical approved for aircraft deicing is propylene glycol, the only aircraft deicer approved for purchase by Air Force (AF) activities. Existing stock of ethylene glycol-based and ethylene glycol (MIL-A-8243D, Type II) deicers may be used until depleted. A Pentagon Operations Directorate issued in July 1993, prohibited the purchase of additional stocks of ethylene glycol-based chemicals for both runway and aircraft deicing. The Navy is the manager of MIL-A-8243D specification for aircraft deicers. The Army uses deicers of this specification when it deices its helicopter rotor blades.

Alternative Materials and Processes for Tactical Vehicle Washing (Land/Sea/Air)

OBJECTIVE: Alternative technologies such as source reduction and material substitution to reduce or eliminate the use, release and off-site transfer of toxic chemicals from tactical vehicle exterior washing processes will be the focus of this program. This may include the development of new or modification of existing equipment or technology, process(es) or procedure(s), reformulation or redesign of products, with possible substitution of materials. It does not include control, treatment or discharge process. In addition the relationship between oil and soil contaminants (oil-soil agglomerations) in the waste stream from tactical vehicle cleaning processes may need to be considered. Current substitute cleaners and their impact on existing waste streams may need to be considered where they have been adopted.

The need to wash various tactical vehicles and aircraft on a regular basis results in vast quantities of soil- and oil-ladened waters some with quantities of environmentally unfriendly detergents. The logistics required to deal with the quantity of runoff and containment of materials will be greatly reduced or eliminated thereby freeing personnel to perform more important operational commitments. The costs involved in containment and separation will likewise be reduced or eliminated.

BACKGROUND: Proper maintenance of DoD's weapon systems and equipment is vital to mission readiness and sustainment as well as to the safety of military and civilian personnel. Tactical vehicle cleaning is one component of this necessary maintenance function. Thorough characterization of the waste streams from tactical vehicle cleaning processes is necessary in order to develop appropriate and cost-effective alternative technologies that reduce or eliminate environmental pollution. For example, a military base can be responsible for hundreds of waste streams associated with the tactical vehicle maintenance and cleaning functions. Source reduction goals for contaminants in the process waste streams cannot be established as a success metric until characterization data are obtained.

Identification of contaminants in waste oil from oily sludge and from floating oils in the process waste stream is necessary to determine the suitability of waste oil for reuse and recycle.

Minimization of Oily and Non-Oily Waste

OBJECTIVE: A two-pronged effort to the problem of oily and non-oily waste is being launched. One is a wastewater minimization effort within the Pollution Prevention Thrust Area and the other is a treatment effort, specifically directed at reducing oil concentration in ship discharges, within the Compliance Thrust Area.

The development of new technologies and processes, and innovative process enhancements which limit or eliminate the generation of oily and non-oily wastes at their source will be the focus of the pollution prevention thrust of this project. Although material substitution is not the focus of this Statement of Need, development of closed loop and recycle processes and technologies which result in the minimization of waste products fall within this requirement. New technology advancements can minimize wastewater and treat wastes at their source to achieve a volume reduction; technologies which produce a reduced, but hazardous, wastewater are not within the scope of this SON. In addition, the development of new technologies pursued hereunder will consider the effect of the minimization process on the existing collection or end-of-pipe treatment equipment such that residual wastes can be collected, transported, and treated by conventional methods as part of the compliance thrust of this project.

BACKGROUND: International, Federal, State, and local environmental regulations limit the discharge of oily and non-oily wastewater from ships and land-based activities into receiving water bodies and sanitary sewers. Wastewater aboard ships is generated by domestic, hotel, and commissary functions, as well as, industrial and machinery maintenance activities. The generation rate depends largely on the number of people on-board, the type of propulsion plant, and the vessel's operational profile; for example, one aircraft carrier generates up to 300,000 gallons per day of sewage and graywater and nearly 100,000 gallons per day of oily waste while steaming. Sources of ship wastes include urinals, water closets, galley and scullery equipment, showers, sinks, auxiliary and propulsion machinery, aircraft launching equipment, and fueling and ballasting systems.

LIST OF ACRONYMS

A/C	Aircraft
AAP	Army Ammunition Plant
ADN	Rocket Motor Propellant Compound
ADAF	Anti-Icing Fluid
ADPA	American Defense Preparedness Association
AEC	Army Environmental Research Center
AFCEE	Air Force Center for Environmental Excellence
AFCESA	Air Force Civil Engineering Support Activity
AFM	Atomic Force Microscopy
AFOSR	Air Force Office of Scientific Research
AH	Attack Helicopter
AHPC	Army High-Performance Computing
AICUZ	Air-Installation Compatible Use Zone
Al	Aluminum
AL	Armstrong Laboratory
ALC	Air Logistics Centers
ANL	Argonne National Laboratory
ANM	Animal Noise Monitor
ANSI	American National Standards Institute
AOP	Advanced Oxidation Process
AQMD	Air Quality Management Districts
ARA	Applied Research Associates
ARDEC	Army Armaments Research, Engineering & Development Center
AREP	Alternative Refrigerant Evaluation Program
ARM	Atmospheric Radiation Measurement
ARPA	Advanced Research Projects Agency
ARS	Agriculture Research Service
ARSAP	Atmospheric Remote Sensing and Assessment Program
ASAN	Assessment System for Aircraft Noise
ASTE	Advanced Strategic and Tactical Expendables
ASTM	American Society for Testing and Materials
ATD	Advanced Technology Demonstration
ATEDS	Advanced Technology Expendables and Dispenser System
ATLAS	Advanced Testing Line for Actinide Separations
ATRP	Automatic Target Recognition Processor
ATOC	Acoustic Thermometry of Ocean Climate
BAA	Broad Agency Announcement
BDC	Background Data Center

BLM	Bureau of Land Management
BOD	Biological Oxygen Demand
BRAC	Base Realignment and Closure
BSAA	Boric-Sulfuric Acid Anodizing
BTEX	Benzene, Toluene, Ethylbenzene, and Xylene
C3P2	Cleanup, Compliance, Conservation, Pollution Prevention
CAA	Chromic Acid Anodizing
CAA	Clean Air Act
CAAA	Clean Air Act Amendments
CAME	Clean Agile Manufacturing of Energetics
CARB	California Air Resources Board
CARC	Chemcial Agent Resistant Coating
CART	Cloud and Radiation Testbed
CATS	Controlled Archeological Test Site
CAV	Composite Armored Vehicle
CCAC	Close Combat Armament Center
CCC	Chromate Conversion Coatings
CCD	Charge Coupled Devices
Cd	Cadmium
CDI	Capacitive Deionization
CE	Civil Engineering
CEMS	Continuous Emissions Monitoring System
CER	Center for Environmental Research
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (called Superfund)
CERL	U.S. Army Construction Engineering Research Laboratory
CFC	Chlorofluorocarbon
CFD	Computational Fluid Dynamics
CHPPM	Center for Health Promotion and Preventive Medicine
CHSSI	Common High-Performance Scalable Software Initiative
CIA	Central Intelligence Agency
CL-20	Hexanthrohexaazaisowurtzitane
CNO	Chief of Naval Operations
COTS	Commercial-off-the-Shelf
CPAT	Corrosion Prevention Advisory Teams
CPC	Corrosion Prevention Compound
CPT	Cone Penetrometer
Cr	Chromium/Chromates
CRADA	Cooperative Research and Development Agreement
CRREL	U.S. Army Cold Region Research and Engineering Laboratory
Cu	Copper
CUSP	Commander, Undersea Surveillance Pacific
CW	Continuous Wave
CWA	Clean Water Act

DAF	DNA Amplification Fingerprint
DCA	Dynamic Contact Angle Analyzer
DCA	Dichloroethane
DCE	Dichloroethylene
DECIM	Defense Environmental Corporate Information Management Program
DEM/VAL	Demonstration/Validation
DERA	Defense Environmental Restoration Account
DFA	Difluoroamino
DFSS	Dedicated Feedstock Supply Systems
DMMF	Developmental Manufacturing and Modification Facility
DNA	Defense Nuclear Agency
DNAPL	Dense Non-Aqueous Phase Liquid
DNB	Dinitrobenzene
DNL	Dry Low NO_x
DoD	Department of Defense
DOE	Department of Energy
DOI	Department of the Interior
DPG	Dugway Proving Ground
DRE	Destruction and Removal Efficiency
DUECC	Defense Utility Energy Coordinating Council
DUSD(ES)	Office of the Under Secretary of Defense Environmental Security
EA	Environmental Assessment
ECIP	Energy Conservation Investment Program
ECU	Environmental Control Unit
EIS	Environmental Impact Statement
EMAA	Encapsulated Micron Aerosol Agents
EMAP	Environmental Monitoring and Assessment Program
EN	Energy Conservation/Renewable Resources Thrust Area
EO	Electro-Optic
EO	Executive Order
EOS	Earth Observing System
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right to Know Act
ERAP	Environmental Risk Assessment Program
ERDEC	US Army Edgewood Research, Development and Engineering Center
ERPM	Emission Reduction Planning Model
ES	Enviroene (EPA Information Umbrella)
ESA	Endangered Species Act
ESTCP	Environmental Security Technology Certification Program
EQT	Environmental Quality Technology Program
EXCEL	Experimental Chloride Extraction Line
FAA	Federal Aviation Administration
FEDS	Federal Energy Decision Screening Model
FEMP	Federal Energy Management Program

FIC	Fluoroiodocarbon
FID	Free-Induction Decay
FORS	Fiber Optic Raman Sensor
FOX	Fluoroalkoxymethyl-3methyl-Oxetane
FTS	Fourier Transform Spectrometer
FUDS	Formerly Used Defense Sites
FWPPCA	Federal Water Pollution Prevention and Control Act
GAC	Granular Activated Carbon
GC	Gas Chromatography
GCDIS	Global Change Distributed Information System
GC/MS	Gas Chromatography/Mass Spectrometry
GEM	Navy Green Energetics Manufacturing
GIMI	Global Imagery Monitor of the Ionosphere
GIS	Geographic Information System
GISS	Goddard Institute for Space Studies
GMS	Groundwater Modelling System
GOCO	Government-Owned/Contractor-Operated
GOES	Geostationary Operational Environmental Satellites
GPR	Ground-Penetrating Radar
GPS	Global Positioning System
GRASS-PRISM	Geographic Resource Analysis Support System - Planning and Resource Integration Stewardship Model
GRFL	Groundwater Remediation Field Laboratory
GSE	Ground Support Equipment
GUI	Graphical User Interface
GV	Grassland Value Function
HAP	Hazardous Air Pollutant
HAZMAT	Hazardous Materials
HAZMIN	Hazardous Waste Minimization
HCFC	Hydrochlorofluorocarbon
HF	Hydrogen Fluoride
HFC	Hydrofluorocarbon
HMX	Octahydro-1,3,5,7-Tetranitro 1,3,5,7-Tetrazocine
HOPS	Heuristic Optimized Processing Systems
HPLC	High Performance Liquid Chromatography
HSRC	Hazardous Substance Research Center
HUD	Department of Housing and Urban Development
HVLP	High Volume Low Pressure
HVTS	High Velocity Thermal Spray
HW	Hazardous Wastes
HWRC	Hazardous Waste Research Center
IBEAM	Installation Baseline Energy Analysis Model
ICA	Incremental Cost Analysis
ICAO	International Civil Aviation Organization

ICUZ	Installation Compatible Use Zone
IDLAMS	Integrated Dynamic Landscape Analysis and Modeling System
IHPTET	Integrated High Performance Turbine Engine Technology
INEL	Idaho National Engineering Laboratory
IPD	Integrated Product Development
IPM	Integrated Pest Management
IPPD	Integrated Product/Process Development
IPT	Integrated Product Team
IR	Infra-red
IRIS	Integrated Risk Information System
IRP	Installation Restoration Program
IUSS	Integrated Undersea Surveillance System
IVD	Ion Vapor Deposited
JATO	Jet Assisted Take Off
JDEP	Joint Depot Environmental Panel
JEMP	Joint Engineers Management Panel
JETC	Jet Engine Test Cell
JHU/APL	John Hopkins University Applied Physics Laboratory
JPG	Jefferson Proving Ground
JPL	Jet Propulsion Laboratory
KDN	Rocket Motor Propellant Compound
LAAP	Louisiana Army Ammunition Plant
LAMS	Laser Ablation Mass Spectroscopy
LANL	Los Alamos National Laboratory
LCA	Life Cycle Assessment
LCAD	Life Cycle Assessment and Design
LCAAP	Lake City Army Ammunition Plant
LCED	Life Cycle Engineering and Design
LCI	Life Cycle Inventory
LG	Logistics
LIBS	Laser-Induced Breakdown Spectroscopy
LIF	Laser-Induced Fluorescence
LIN	Liquid Nitrogen
LIS	Laser Ignition System
LLNL	Lawrence Livermore National Laboratory
LMS	Lead Hazard Mitigation Management System
LNAPL	Light Non-Aqueous Phase Liquid
LOVA	Low Vulnerability Ammunition
LRS&T	Long Range Science and Technology Program
MADOM	Magnetic and Acoustic Detection of Mines
MAFB	McClellan Air Force Base
MAJCOM	Major Commands
MALDI	Matrix Assisted Laser Desorption Ionization
MAOP	Mobile Meteorological Observation Platform

MARPOL	International Maritime Organizations Marine Pollution Convention
MARS	Mobile Analytical Reconnaissance System
MAS	Millimeter-Wave Atmospheric Sounder
MB/MS	Molecular Beam/Mass Spectrometric
MCB	Marine Corp Base
MCRA	Material/Chemical Risk Assessment
MCFC	Molten Carbonate
MDA-E	McDonnell-Douglas Aerospace-East
MECL	Methylene Chloride
MEK	Methyl Ethyl Ketone
MIC	Metastable Inerstitial Composites
MIDAS	Munitions Items Disposal Action System
MIPR	Military Interagency Purchase Request
MIT	Massachusetts Institute of Technology
MM	Modifier Molecules
MMATS	Marine Mammal Acoustic Tracking System
MMPA	Marine Mammals Protection Act
MMRP	Marine Mammal Research Program
Mn	Manganese
MODIS	Moderate-Resolution Imaging Spectroradiometer
MPC	Mobile Power Center
MR/H	Mine Reconnaissance/Hunter
MRTFB	Major Range and Test Facility Base
MTR	Military Training Routes
MTV	Magnesium-Teflon-Viton
MUDSS	Mobile Underwater Debris Survey System
MWCO	Molecular Weight Cutoff
MWOs	Modification Work Orders
NAAQS	National Ambient Air Quality Standards
NADEP	Naval Depots
NAGPRA	Native American Grave Protection and Repatriation Act
NAPL	Non-Aqueous Phase Liquid
NASA	National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organization
NAX	Natural Attenuation of Explosives
NBS	National Biological Survey
NC	Nitrocellulose
NCAR	National Center for Atmospheric Research
NCBC	Navy Construction Battalion Center
NCMS	National Center for Manufacturing Sciences
NDCEE	National Defesne Center for Environmental Excellence
NDFT	Non-local Density Functional Theory
NDI	Non-Developmental Item
NEPA	National Environmental Policy Act

NESHAP	National Emission Standard for Hazardous Air Pollution
NETTS	National Environmental Technology Test Sites
NG	Nitroguanidine
NGB	National Guard Bureau
NGFSTP	Next Generation Fire Suppression Technology Program
NHPA	National Historic Preservation Act
Ni	Nickel
NMERI	New Mexico Engineering Research Institute
NMFS	National Marine Fisheries Service
NMR	Nuclear Magnetic Resonance
NOAA	National Oceanic and Atmospheric Administration
NOV	Notice of Violation
NOx	Nitrogen Oxide(s)
NPS	National Park Service
NRaD	Naval Research and Development Center
NRC	National Research Council
NRHP	National Register of Historic Places
NRL	Naval Research Laboratory
NRMRL	National Risk Management Research Laboratory
NSPS	New Source Performance Standards
NSWC	Naval Surface Warfare Center
NTIS	National Technical Information Service
NTL	National Test Location
NTP	Non-Thermal Plasma
OB/OD	Open Burning/Open Detonation
OC-ALC	Oklahoma City Air Logistics Center
ODC	Ozone Depleting Chemicals
ODOBi	High Explosive Capacity Facility for Open Burning/Open Detonation Testing
ODUSD(ES)	Office of the Deputy Under Secretary of Defense for Environmental Security
ODS	Ozone Depleting Substances
OEM	Original Equipment Manufacturer
ONR	Office of Naval Research
OPNAV	Naval Operations, Headquarters Staff (Pentagon)
OPNAVINST	Naval Operations Instruction
OSHA	Occupational Health and Safety Act
OTD	Office of Technology Development
PAFC	Phosphoric Acid Fuel Cells
PAH	Polycyclic Aromatic Hydrocarbons
Pb	Lead
PCA	Tetrachloroethane
PCB	Polychlorinated Biphenyls
PCE	Perchloroethylene (tetrachloroethylene)

PCR	Polymerase Chain Reaction
PEO	Program Executive Officer
PEO/FAS	Program Executive Officer for Field Artillery Systems
PEP	Propellants, Explosives, Pyrotechnics
PG	Propylene Glycol
PI	Principal Investigator
PM	Particulate Matter
PM	Program Manager
PMB	Plastic Media Blasting
PNL	Pacific Northwest Laboratory
POAM	Polar Ozone and Aerosol Monitor
POL	Petroleum, Oil, Lubricants
PP	Pollution Prevention Thrust Area
PTT	Platform Transmitting Terminals
PVD	Physical Vapor Deposition
PVRC	Photovoltaic Review Committee
QA/QC	Quality Assurance/Quality Control
QMP	Quality Management Plan
RACER	Remedial Action Cost Engineering and Requirements
RAIDS	Remote Atmospheric and Ionospheric Detection System
RASS	Radio Acoustic Sounding System
RBCA	Risk-Based Corrective Action
RCI	Rapid Commercialization Initiative
RCRA	Resource Conservation and Recovery Act
RDT&E	Research, Development Test & Evaluation
RDX	Hexahydro-1,3,5-trinitro-1,3,5-triazine
REEP	Renewable and Energy Efficiency Planning
RMA	Rocky Mountain Arsenal
ROD	Record of Decision
RREL-EPA	Risk Reduction Engineering Laboratory - Environmental Protection Agency
RSKERL	Robert S. Kerr Environmental Research Laboratory
RTDF	Remediation Technologies Development Forum
RTG	Room Temperature Gradiometer
S&T	Science and Technology
S-O&CS	Smokes, Obscurants & Chemical Simulant Agents
SAB	Scientific Advisory Board
SAPT	Symmetry Adapted Perturbation Theory
SAR	Structural Activity Relationships
SAR	Synthetic Aperture Radar
SBAA	Sulfuric-Boric Acid Anodize
SBIR	Small Business Innovation Research
SCAMP	Subsurface Cleanup and Mobilization Processes
SCAPS	Site Characterization and Analysis Penetrometer System
SCF	Supercritical Fluid

SCWO	Supercritical Water Oxidation
SDI	Strategic Defense Initiative
SEM	Scanning Electron Microscope
SERDP	Strategic Environmental Research and Development Program
SERS	Surface Enhanced Raman Sensor
SF	Supercritical Fluid
SFC	Specific Fuel Consumption
SFE	Supercritical Fluid Extraction
SIFDT	Selected Ion Flow-Drift Tube
SMCA	Single Manager for Conventional Ammunition
Sn	Tin
SNAP	Significant New Alternatives Policy
SNL	Sandia National Laboratory
SNRM	Strategic Natural Resources Management
SO_2	Sulfur Dioxide
SOFAR	Deep Sound Conducting Channel
SOP	Standard Operating Procedure
SOSUS	Sound Surveillance System
SOTA	State-Of-The-Art
SRS	Savannah River Site
SRTC	Savannah River Technology Center
STR	Synthetic Tandem Repeat
SVE	Soil Vapor Extraction
SW	Shallow Water
TAMU	Texas A&M University
TAP	Technical Advisory Panel
TARA	DoD Environmental Technology Area Review & Assessment
TCA	Trichloroethane
TCE	Trichloroethylene
TDL	Tunable Diode Laser
TES	Threatened and Endangered Species
TET	Tetryl
TIPPP	Tidewater Interagency Pollution Prevention Program
TIWET	The Institute for Wildlife and Environmental Toxicology
TL	Transmission Loss
TLM	Test Location Manager
TNAZ	1,3,3-Trinitroazetidine
TNB	Trinitrobenzene
TNT	Trinitrotoluene
TPE	Thermal Plastic Elastomer
TTAWG	Technology Thrust Area Working Group
TRI	Toxic Release Inventory
TRU	Transuranic Radioactive Waste
TV	Trapped Vortex

TVC	Trapped Vortex Combustor
TSVP	Thermal Spray Vitrification Process
UARS	Unmanned Air Reconnaissance System
UAV	Unmanned Aerospace Vehicle
UB	Ultra Broadband
UFA	Unsaturated Flow Apparatus
UFAL	Ultra-Fine Aluminum
UM	University of Minnesota
USACERL	U.S. Army Corps of Engineers, Construction Engineering Research Laboratories
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USFWS	US Fish and Wildlife Service
USGCRP	U.S. Global Change Research Program
USGS	U.S. Geological Survey
UST	Underground Storage Tank
UVB	Proprietary groundwater circulation well design
UVRS	Ultraviolet Remote Sensing
UWB	Ultra Wide Band
UXO	Unexploded Ordnance
VAAP	Volunteer Army Ammunition Plant
VLA	Vertical Line Arrays
VNTR	Variable Number of Tandem Repeats
VOC	Volatile Organic Compound
VPI	Virginia Polytechnic Institute and State University
WAFB	Wurtsmith Air Force Base
WES	U.S. Army Engineer Waterways Experiment Station
WEPP	Water Erosion Prediction Project
WIC	Water-Injection Combustor
WHV	Wildlife Habitat Value Function
WR	Water Reducible
WS	Weapon Systems
WWW	World-Wide Web
XAS	X-ray Absorption Spectroscopy
XCRIS	X-windows-based Cultural Resource Information System
XPS	X-ray Photo-Electron Spectroscopy
XRD	X-ray Diffraction
XRF	X-ray Fluorescence
XRS	X-ray Spectrometry
Zn	Zinc

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